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# THE INTERNET AND HIGHER EDUCATION

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# The Internet and Higher Education

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**STATEMENT OF PURPOSE:** *The Internet and Higher Education* is a quarterly journal devoted to addressing contemporary issues and future developments related to online learning, teaching, and administration on the Internet in post-secondary settings. It is a peer-reviewed journal intended to be a vehicle for scholarly presentation and dissemination of contributions, theoretical and applied, significantly addressing innovative deployments of Internet technology in instruction and reporting on research to demonstrate the effects of the Internet and information technology (IT) on instruction in various contexts in higher education. The journal is international and interdisciplinary, inviting contributions from across the globe and from various academic disciplines. The journal provides a venue for theory papers, research studies, critical essays, editorials, reviews, case studies, and social commentary contributions. Special issues are often devoted to specific topic areas with guest editors assisting in the editorial process.

The scope of the journal is broad in terms of the range of issues and trends to be addressed, for example, innovations or best practices in online teaching, learning, management, and administration. Other issues may include: Internet technology design and use; instructional models in online courses; online course development and instructional design; interaction in online courses; collaborative learning; usability and evaluation of online environments and portals; online communities of practice; institutional policies, standards and assessment; accessibility standards in online instruction; internationalization and cultural aspects of online classrooms; and issues and trends in synchronous, asynchronous, and hybrid online learning.

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# Virtually unlimited classrooms: Pedagogical practices in massive open online courses

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ABSTRACT

Massive open online courses (MOOCs) have become a prominent feature of the higher education discourse in recent years. Yet, little is known about the effectiveness of these online courses in engaging participants in the learning process. This study explores the range of pedagogical tools used in 24 MOOCs, including the epistemological and social dimensions of instruction, to consider the extent to which these courses provide students with high-quality, collaborative learning experiences. Findings suggest that the range of pedagogical practices currently used in MOOCs tends toward an objectivist-individual approach, with some efforts to incorporate more constructivist and group-oriented approaches. By examining MOOCs through the lens of engaged teaching and learning, this study raises concerns about the degree to which MOOCs are actually revolutionizing higher education by using technology to improve quality, and challenges educators to strive for more creative and empowering forms of open online learning.

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## 1. Introduction

Online education is the fastest growing segment of higher education (Deming, Goldin, & Katz, 2012). More than 6.1 million students participated in a fully online course during fall 2010, a 10 percent increase over the previous year (Allen & Seaman, 2011). Online instruction, including web-facilitated, blended, hybrid, and fully online courses, has become a fixture of the higher education landscape during the past twenty years, with private, public, and for-profit institutions offering individual courses and degree programs that attempt to replicate and build upon the traditional classroom experience. In 2012, one particular form of online learning – the massive open online course (MOOC) – took center stage in the discourse and sparked debate about the potential of open online education to solve the challenges of access and affordability in higher education. In fact, *The New York Times* went so far as to declare 2012 as "The Year of the MOOC," (Pappano, 2012).

A MOOC is a model for education delivery typically defined as, "*massive*, with theoretically no limit to enrollment; *open*, allowing anyone to participate, usually at no cost; *online*, with learning activities typically taking place over the web; and a *course*, structured around a set of learning goals in a defined area of study" (Educause, 2013, p. 1). Instructors at hundreds of colleges and universities around the world are now offering MOOCs in a broad range of disciplines, from Dinosaur Paleobiology at the University of Alberta to Shakespeare at Wellesley College to Corporate Finance at the University of Pennsylvania. At the same time, a handful of key players, including Coursera, edX, and Udacity, have been instrumental in the development of the movement. According to Daphne Koller, co-founder of Coursera, MOOCs will transform, not disrupt, higher education and leverage technology to improve quality (Korn, 2013). She states, "We don't believe that computers should replace teachers. We think computers can enhance the work of teachers" (Korn, 2013, para. 17).

As a relatively new phenomenon in higher education, research related to MOOCs is limited. These open courses have the potential to challenge traditional notions of classroom, and even online, instruction, yet few empirical studies have examined student learning in MOOCs and little is known about the ways that these courses may challenge the growing stratification of educational opportunities globally. The original MOOCs set out to create an open, collaborative online learning community centered around "the active engagement of several hundred to several thousand 'students' who self-organize their participation according to learning goals, prior knowledge and skills, and common interests," (McAuley, Stewart, Siemens, & Cormier, 2010, p. 4). These learner-centered pedagogical practices and constructivist approaches encouraged student engagement in the learning process. Yet, in many ways the goals of the MOOC movement have shifted to encompass the massification of existing courses and the potential for revenue generation, with elite American universities and private companies leading the charge. The purpose of this study is to consider the extent to which MOOCs provide students with high-quality, collaborative learning experiences. Through case study analysis, we examine the range of pedagogical practices utilized in 24 MOOCs offered by a diverse group of providers and consider how these practices contribute to student engagement in the learning process.

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Three main research questions guide the study, including: (1) What instructional tools and pedagogical practices are being utilized in MOOCs? (2) How are new digital and networked technologies impacting the delivery of MOOCs? (3) To what extent are MOOCs able to provide a space for critical inquiry and active student engagement in the learning process? In the following section, we will provide a brief introduction to the relevant literature on MOOCs and student engagement in online learning environments. We will then discuss the study methodology, including constructivist learning theories and study methods, followed by a presentation of study findings and a discussion of the range and role of pedagogical practices in MOOCs.

## 2. Literature review

Massive open online courses (MOOCs) have grown out of the Open Educational Resources (OER) movement that flourished in the 1990s, when new online technologies paved the way for interactive and collaborative computer-based learning (Bonk, 2009). OER is defined as educational resources offered online for free to educators, students, and self-learners to enhance teaching and learning (McMartin, 2008; Organization for Economic Cooperation and Development [OECD], 2007). The OER movement "aims to break down…barriers and to encourage and enable sharing content freely" (OECD, 2007, p. 30). Advocates argue that open online education enhances higher education by increasing access to educational materials previously reserved for a limited number of enrolled students and by improving instruction through shared materials and the feedback among educators and learners (Bissell, 2009; Huijser, Bedford, & Bull, 2008). Successful implementation requires a combination of technology, support from faculty and institutional leaders, open licensing, and a diverse community of educators and learners ready to engage in the process (Bissell, 2009; McMartin, 2008). As digital technologies progressed to facilitate more advanced online interaction and collaboration, the principles of OER have been utilized to develop a new kind of open online course.

### *2.1. Massive open online courses*

The term "massive open online course," or MOOC, was first used to describe a course on learning theory taught by George Siemens and Stephen Downes at the University of Manitoba in 2008. According to Downes, the idea was to "invite the rest of the world to join the 25 students who were taking the course for credit" (Parry, 2010, para. 2). The course attracted 2300 students, and has since become "a landmark in the small but growing push toward 'open teaching'" (Parry, 2010, para. 4). The innovative 12-week open online course, Connectivism and Connective Knowledge, was designed as a collaborative learning experience. According to the 2011 course website, the course was based on four types of activities, namely: (1) to "aggregate" materials, or select course readings and resources of interest to the individual; (2) to "remix" those materials, or catalog the chosen content on a blog, discussion board, or other interactive format; (3) to "repurpose" tools to create one's own content and contribution to the discourse; and (4) to "feed forward" one's own thoughts and interpretations in a public forum (http://cck11.mooc.ca/). Students were not required to share their materials publicly but it was encouraged as an integral part of connectivist learning.

Siemens (2005a) and Downes (2007) have advanced a connectivist theory of learning that integrates principles of chaos, network, complexity, and self-organization theories. According to Siemens (2005a), rapid advances in information and communication technology have changed the landscape of learning and knowledge production, and "including technology and connection making as learning activities begins to move learning theories into a digital age" (p. 3). Within the theory, learning networks encompass data, information, knowledge and meaning, and the optimal environment for meaning generation is an open, adaptive, and reflective network that recognizes patterns and incorporates both cognition and emotional response. Siemens (2005b) argues that more emphasis should be placed on advancing the learner's skills in navigating and analyzing information. For Siemens, Downes, and other advocates of open learning, the MOOC grew out of a desire to utilize technology to create a platform for greater access, collaboration and engagement in the learning process.

According to Cormier and Gillis (2010), a MOOC is an online course that engages students in the learning process, offers a way for students to connect and collaborate, and provides a platform where course materials are shared and negotiated among participants. MOOCs also emphasize participant autonomy, creating a broad form of legitimate peripheral participation where individuals negotiate their own level of engagement (McAuley et al., 2010). The pedagogical model driving the initial development of MOOCs focused on incorporating high levels of learner control, offering synchronous, or real-time, sessions with the facilitator and other speakers, providing a digital artifact that summarized course activities (i.e. participant blogs, posts, online discussion, external resources), developing dynamic social systems as a means of participant organization and collaboration, and emphasizing the criticality of creation in the learning process (McAuley et al., 2010). Further, the early MOOCs were designed to be tuition-free, openly accessible courses that did not generally incorporate formal assessment or grading (Levy, 2011).

MOOCs hit the mainstream in 2012 when private companies including Coursera and Udacity were established, and set out to partner with top U.S. universities to develop these open courses for mass consumption, and potential revenue generation. As mentioned previously, MOOCs took center stage in the higher education discourse during this period with enthusiasts pointing to the power of technology to lower costs, increase access, and generate support from industry and the public at large. Advocates argue that MOOCs are helping to revolutionize higher education because "nothing has more potential to lift more people out of poverty" by providing access to an affordable education for employment (Friedman, 2013, para. 1). Further, they note that these courses offer an alternative to location-based education and "undermine the individually crafted course model that sustains the 'college credit monopoly'" (Mazoué, 2013, para. 5). Yet not everyone is convinced that MOOCs will "disrupt" higher education in such positive and productive ways. Many faculty members and higher education analysts remain skeptical that MOOCs offer a viable alternative to traditional face-to-face or online education models with regard to instruction, student learning, and access (Allen & Seaman, 2013; Lewin, 2013; Meisenhelder, 2013; Rhoads, Berdan, & Toven-Lindsey, 2013).

Empirical research on teaching strategies and learning outcomes associated with MOOCs is limited. As courses designed to accommodate unlimited enrollments, MOOCs offer minimal support mechanisms and require that participants be self-directed and have a level of critical literacy adequate to navigate the course and engage in the learning community (Kop, 2011). While more experienced and independent students may thrive in this environment, many participants struggle with the lack of structure and instructional support inherent in these courses (Kop, Fournier, & Mak, 2011). In addition, the commercialization of educational materials is changing the way institutions of higher education interact with the private-sector marketplace and share knowledge with students and society at large (Rhoades & Slaughter, 2004). Considering the limitations of research related to MOOCs, studies of student engagement and pedagogy in traditional online learning environments offer a useful point of reference for this study.

### *2.2. Engagement and pedagogy in online learning communities*

Online learning has become an increasingly important part of U.S. higher education throughout the past several decades, with more than 30% of all college students participating in at least one online course (Allen & Seaman, 2011). By utilizing the latest computer-mediated technology, online courses offer students a wide range of engaging and interactive learning environments that have been shown to foster satisfaction, motivation, and persistence among participants (Arbaugh

& Benbunan-Fich, 2006; Kuh, 2003; Morris, Finnegan, & Wu, 2005; Swan, 2001). Intentional course design that facilitates structured peer interaction, including discussion boards, wikis, and video conferencing, contributes to active learning and critical reflection (Song, Singleton, Hill, & Koh, 2004; Swan, 2001).

Online courses encourage students, as independent learners, to develop skills of personal reflection and abstract conceptualization (Aragon, Johnson, & Shaik, 2002; Vonderwell, Liang, & Alderman, 2007). Yet, Garrison, Anderson, and Archer's (2010) model for a "community of inquiry" in computer-mediated learning environments articulates the need for social presence, cognitive presence, and teaching presence to facilitate critical inquiry and collaborative learning. They argue that online courses should be designed to facilitate meaning making and authentic personal interactions.

Instructors in traditional online learning spaces, with limited enrollments and fixed timelines, are often active participants in the learning process and interact with students on a regular basis despite the lack of face-to-face class time. Research indicates that students in online courses may be more successful and satisfied when instructors provide clear objectives and requirements for the course (Morris et al., 2005), focus on creating a collaborative learning environment (Arbaugh, 2000), offer high levels of instructor–student interactions (Swan, 2001), and deliver meaningful feedback to participants (Eom, Wen, & Ashill, 2006).

While research related to traditional online learning environments provides a strong foundation for the development of effective teaching practices in MOOCs, these open access courses present new challenges for instructors and learners. Therefore, a critical analysis of the pedagogical practices used in MOOCs is both timely and instructive. Ongoing evaluation, feedback from users, and pedagogical considerations are essential to the growth and success of open online education (Thille, 2008).

## 3. Engaged teaching and learning

Student-centered pedagogy has taken a more prominent position within the higher education discourse in recent decades as educators have challenged traditional modes of teaching focused on lectures and testing (Hannafin & Land, 1997; Mascolo, 2009). In a student-centered approach, the instructor guides and supports students as they develop their own understanding of the concepts as opposed to sharing relevant information and expertise with a passive recipient. Advances in instructional technology have also contributed to this discussion. Learner-centered technologies can offer "greater opportunity to experience learning activities that are internally driven and constructed, goal oriented and reflective, personally meaningful and authentic, collaborative and socially negotiated, and adaptive to individual needs and cultural backgrounds" (Bonk & Cunningham, 1998, pg. 30). As the physical location of participants becomes less important, students' interests and expertise coupled with the use of appropriate pedagogical tools can be a determining factor in creating an engaging and collaborative online community.

Learner-centered education draws its origins from constructivist development theory and the progressive education movement of the 1990s (Mascolo, 2009). Within the constructivist epistemology, there are two main approaches including cognitive constructivism and social constructivism (Powell & Kalina, 2009). Cognitive constructivism focuses on the individual development of knowledge through interaction with the environment, while social constructivism is concerned with student dialogue, interaction, negotiation and the social context in which learning takes place (Bonk & Cunningham, 1998). According to socio-cultural theorists, learning is an integral part of human participation in the world and is influenced by both cognitive and social processes (Lave & Wenger, 1991; Vygotsky, 1978).

Cognitive constructivism is rooted in Piaget's theory of cognitive development, which argues that humans must construct their own knowledge as opposed to merely receiving information (Powell & Kalina, 2009). Instruction therefore focuses on students' understanding of primary sources and interactive materials, including open-ended questions that promote personal inquiry and discovery. Collaboration and peer interaction may be part of the learning but their importance is in modeling and supporting the development of new individual metacognitive skills (Bonk & Cunningham, 1998).

Social constructivism, on the other hand, places dialogue and collaboration at the center of the learning process. Based on Vygotsky's theories of development, social constructivism focuses on the ways that one's environment and interactions, along with various forms of support and scaffolding, impact the individual learning process (Lave & Wenger, 1991; Powell & Kalina, 2009). Cognition is therefore not solely an individual phenomenon but one rooted in social and cultural interaction (Kaptelinin, 1996; Kozulin, Gindis, Ageyev, & Miller, 2003), and meaning is negotiated through language, interaction, and activity (Lave, 1991). "Knowledge is created and recreated between people, as they bring their personal experience and information derived from other sources to bear on solving some particular problem" (Wells, 2000, p. 63). Individual learning is dependent on the institutions, settings, and cultural context of the learner (Bonk & Cunningham, 1998).

Situated learning theory, as advanced by Lave (1991), draws from both cognitive and social constructivism and argues that "learning, thinking and knowing are relations among people engaged in activity in, with and arising from the socially and culturally structured world" (p. 67). From this view, individuals are engaged in communities of practice, and move from peripheral participation to a more engaged, central position as their expertise and connection to the community increase (Lave, 1991). Curriculum is grounded in real world contexts, and instructors focus on mentoring and coaching students to encourage exploration and reflection among participants. Learners engage in socio-cultural transformation in the context of shared practice, whether activities are completed alone or in collaboration with members of a given community (Lave & Wenger, 1991). As stated previously, McAuley et al. (2010) argue that collaborative MOOCs offer students the opportunity to engage in legitimate peripheral participation since these courses are based on learner autonomy and self-directed engagement in the online community of learners.

Critical pedagogy, as defined by Giroux (2001), is closely aligned with theories of constructivism and situated learning. According to Giroux, pedagogy is more than the simple transmission of expertise. Students construct knowledge through careful personal reflection and collaboration with the instructor and their peers. In addition, individuals benefit from the opportunity to connect course content to their own experiences and social context. Giroux (2011) argues that universities have become more closely aligned with the marketplace and corporate interests, to the detriment of public space and critical inquiry. Instead of focusing on the development of a substantive democracy, corporate interests encourage self-interest and consumerism, and education runs the risk of becoming little more than job training. In contrast, Giroux's (2011) concept of "public time" focuses on pedagogical practices where all participants engage in critical dialogue, affirming their role as social agents. For Giroux, all forms of higher education should provide a space for dialogue, questioning, and dissent, even in fields and courses dominated by objectivist approaches to teaching and learning. It is important then that online learning does not expand access at the expense of collaborative learning communities and opportunities for critical engagement in the learning process.

### *3.1. Collaborative learning in online environments*

Constructivist theories of learning have become an important feature of many online learning environments. Herrington and Oliver (1999) assert that meaningful learning can be achieved using computer technology when it is positioned within the social, cultural, and physical context of the learner, and the activities are authentic and practical. Vygotsky's notion of collaborative learning can be seen in online

learning environments that use computer-mediated speech and text as forms of modeling, and that enhance individual cognition by providing space for reflection and revision of written artifacts (Warschauer, 1997). "The text-mediational view links the concepts of expression, interaction, reflection, problem solving, critical thinking, and literacy with the various uses of talk, text, inquiry, and collaboration in the classroom" (Warschauer, 1997, p. 472). With major advances in social media and other networked technology such as video conferencing and file sharing platforms, online collaboration has become even more fluid and dynamic.

As previously stated, establishing a strong sense of community among online learners has been shown to encourage higher levels of satisfaction, persistence, engagement, and cognition (Morris et al., 2005; Rovai, 2002; Swan, 2001). Inter-subjectivity, or the development of shared understanding, also contributes to student learning because as individuals find common ground they are able to contribute ideas, test assumptions, negotiate meanings, and build new knowledge (Bonk & Cunningham, 1998). Further, Lai (2011) points out that online education opens the door to more fluid movement between formal and informal learning environments, and the opportunity to prepare students to be self-directed, life-long learners. The strategies that students utilize in formal learning environments can encourage critical inquiry and engagement in social networking sites and interest-based communities. At the same time, students engage in different strategies while participating in these less formal settings, which in turn can influence formal learning communities.

The Community of Inquiry framework (Garrison, Anderson, & Archer, 2001, Garrison et al., 2010), discussed previously, provides a useful point of reference for constructivist practices in online learning environments. According to Garrison (2007), cognitive presence "is defined as the exploration, construction, resolution and confirmation of understanding through collaboration and reflection in a community of inquiry" (p. 65). Ideally, participants would move beyond a basic understanding of a particular problem toward a more holistic view that incorporates the integration and application of various concepts. Yet, research indicates that this type of collaborative inquiry does not often move beyond the first stage and teaching presence, or the role of the instructor, may be an important factor in predicting this more complex analytical approach (Garrison, 2007). Student-centered teaching approaches such as scaffolding, modeling, and providing ongoing feedback and encouragement, can go a long way in helping individuals and learning communities gain a deeper understanding of course concepts (Bonk & Cunningham, 1998). According to Garrison (2007), effective teaching presence incorporates course design, facilitation, and direct instruction, and encourages instructors to be highly engaged in the learning process without dominating the discourse and limiting opportunities for student collaboration.

## 4. Methodology

As previously discussed, MOOCs challenge traditional notions of teaching and learning by moving beyond the limits of time and place to include any student who wishes to participate. In this study, we investigate the various instructional techniques present in MOOCs and consider how these tools might impact student engagement in the learning process. To support this line of inquiry, we utilize a framework developed by Arbaugh and Benbunan-Fich (2006) to examine the epistemological and social dimensions of teaching in online education.

### *4.1. Teaching Approach Framework*

Arbaugh and Benbunan-Fich (2006) developed a theory-driven framework to "examine the relationship between teaching approaches and online learning environments in terms of student learning and satisfaction" (p. 436). As illustrated in Table 1, their Teaching Approach Framework is based on the epistemological and social dimensions of instruction, including two intersecting continua from objectivist to constructivist knowledge and individual to group learning. These four teaching approaches encompass a broad range of pedagogical practices in online learning environments.

In the Teaching Approach Framework, objectivist and constructivist dimensions are used to consider "how knowledge is delivered to the students" while the continuum of individual to group learning focuses on the social dimensions of cognition, or "whether learning is expected to occur by way of individual or group-based methods" (p. 436). According to Arbaugh and Benbunan-Fich (2006), the main assumption of the objectivist approach is a "single objective reality" while the goal of learning is to "understand and assimilate that reality" (p. 436). In contrast, a constructivist method is based on the assumption that knowledge is created and developed by learners.

The constructivist-individual approach assumes that "knowledge is constructed in the students' head" while the constructivist-group approach assumes that knowledge is "socially constructed in the world" (p. 436). Instead of solely providing students with instructional sequences, constructivist teachers utilize problem solving and meaningful tasks based on context. This constructivist-group approach aligns with notions of engaged and critical pedagogy where students are active participants in the learning process, articulate their beliefs, and connect their education to real-world experiences (Giroux, 2011; Hooks, 2009). This framework is a useful tool to consider the wide range of pedagogical tools being used in MOOCs, and how various teaching approaches impact learning and engagement among participants.

### *4.2. Methods*

This study utilizes qualitative multi-case study analysis to examine the wide range of pedagogical practices used in MOOCs. A case study involves a thorough examination of a particular event, subject, or phenomenon (Bogdan & Knopp Biklen, 2007; Cohen, Manion, & Morrison, 2000) with special attention to the surrounding context and circumstances (Creswell, 2014; Merriam, 1998). It does not have to involve a single person but can represent "whatever 'bounded system'… is of interest" (Stake, 1978, p. 7). Case studies focus on "holistic description and explanation" and provide a framework for a deeper understanding of a particular phenomenon through thick description and the illumination of broader meaning (Merriam, 1998, p. 192–193). In this study, we define the case as a single MOOC and we examined 24 such cases.

#### *4.2.1. Sample*

We utilized Biglan's (1973) model for categorizing academic disciplines to select 24 university-level MOOCs that represent a broad range of topics and disciplines, including the social sciences, humanities and STEM fields (see Table 2). Biglan clusters academic disciplines along three dimensions based on subject matter: (1) hard and soft sciences, as defined by the degree to which foundational and agreed-upon paradigms shape the field, (2) pure and applied (relating to the level of practical application), and (3) "concern with life systems" (p. 204).

Our goal in this study was not to provide a comprehensive list of MOOCs but instead we present a diverse sample of courses and instructional tools and offer a critical analysis of their implications for course design and student engagement. Through purposive case sampling (Arnold, 1970), we selected MOOCs from 16 course platforms that represent a broad range of open course content and delivery, and included public and private universities, private companies, and not-for-profit enterprises. For a complete list of course providers included in this study, see Appendix A.

#### *4.2.2. Data collection*

Participant observation is a primary source of data collection for observational case study analysis (Bogdan & Knopp Biklen, 2007). This study presented an atypical environment for observation in that MOOCs have no physical meeting place and accommodate unlimited

**Table 1**
Teaching Approach Framework (Arbaugh & Benbunan-Fich, 2006).

| | | Social dimension | |
|---|---|---|---|
| | | Individual | Group |
| Epistemological dimension | Objectivist | Single objective reality.<br>Knowledge is transmitted.<br>Abstract instruction out of context.<br>Emphasis on instructional sequences.<br>Individual mastery of material.<br>Emphasis on learner–instructor interaction. | Single objective reality.<br>Knowledge is transmitted.<br>Instructional sequence combined with group activities.<br>Working with peers reinforces learning and contextualizes concepts.<br>Emphasis on learner–instructor and learner–learner interaction. |
| | Constructivist | Multiple realities.<br>Knowledge is created individually.<br>Engagement with the subject matter.<br>Authentic tasks in meaningful contexts.<br>Emphasis on learner content interaction. | Multiple realities.<br>Knowledge is created.<br>Collaborative construction of knowledge by interacting with peers.<br>Authentic/meaningful group tasks.<br>Emphasis on learner–content and learner–learner interaction. |

student enrollment. Therefore, the research team collected data by reviewing the curriculum and content of the online courses and carefully categorizing pedagogical practices. As open-access courses, MOOCs do not require participants to provide personal information, engage with fellow students, or even complete their coursework and all course-related materials are publicly available to any interested party. Therefore, the research team was able to observe the various instructional elements present in each course without impacting the learning experience of other participants.

Lincoln and Guba (1986) argue that naturalistic inquiry requires rigorous methods, including prolonged engagement, triangulation, and thick narrative description, to strive for trustworthiness and authenticity in results. To gain a deeper understanding of the structure, design, context, and range of instructional tools used in the sample MOOCs, we surveyed the various teaching methods, completed select course modules, exams, and activities, and followed online discussion boards and other collaborative components. Students can generally move through MOOCs at their own pace, and, therefore, we were able to spend significant time examining course material and the different instructional elements of each course without concern for limited access or availability of materials.

#### *4.2.3. Data analysis*

We used Arbaugh and Benbunan-Fich's (2006) Teaching Approach Framework to identify and categorize the various pedagogical tools present in the sample, including course schedules, lessons and content, assignments, quizzes and exams, grading, student collaboration, instructor interaction, and any additional resources. It should be noted that while Arbaugh and Benbunan-Fich employ their framework to articulate the cumulative teaching approach used in an online course, we used the four categories – objectivist-individual, objectivist-group, constructivist-individual and constructivist-group – to characterize the various pedagogical approaches used in different components within each course in the sample (we found it impossible to categorize an entire course given the array of teaching modalities employed in any one course). The goal of this study is to gain a better understanding of the range of pedagogical tools used in MOOCs, and it is therefore instructive to examine individual course components, such as lectures, exams, and discussions, in this manner. Table 3 provides information about the teaching approaches used in each course.

**Table 2**
MOOCs included in the study, according to the Biglan model.

| | Hard | Soft |
|---|---|---|
| Pure life | Biology | Philosophy |
| | Biology | Sociology |
| | Biology | Social theory |
| Pure non-life | Statistics | Geography |
| | Statistics | English composition |
| | Physics | Poetry |
| Applied life | Medicine | Health and climate |
| | Nursing | Law |
| | Public health | Gaming |
| Applied non-life | Chemical engineering | Product development |
| | Engineering | Development economics |
| | Computer graphics | Macroeconomics |

## 5. Findings

The introduction of MOOCs into the higher education landscape is challenging the way educators conceptualize teaching and learning, and traditional notions of online education. Instead of offering online courses with limited enrollments and finding ways to encourage student–instructor interaction online, MOOCs often rely on automated instructional tools to take the place of real-time teaching. Although there is significant variation in pedagogical approaches, the majority of courses still utilize elements that are common in traditional classrooms, including lectures, multiple-choice assessments, and topical group discussions. In the following sections, we present our findings using the four categories of the Teaching Approach Framework. Tables 4 through 7 also provide an overview of the modes of instruction, assessment, and interaction found in each course.

### *5.1. Objectivist-individual approach*

All of the MOOCs included in this study utilized the objectivist-individual approach in some way, as seen in Table 3. This instructional approach relies on the assumption of a single objective reality, and focuses on the transmission of knowledge with an emphasis on instructional sequence and individual mastery (Arbaugh & Benbunan-Fich, 2006). It is not surprising that MOOCs would feature extensive use of an objectivist-individual teaching method considering that nearly all forms of traditional face-to-face teaching and online learning utilize this approach. Teaching and learning inherently involve the transfer of information from an expert to the novice, and therefore it can be useful and efficient to use the objectivist-individual approach. At the same time, research indicates that students are more satisfied with online courses that include higher levels of interaction and reflection (Arbaugh, 2000; Vonderwell et al., 2007).

The courses in this study utilized a range of instructional tools to facilitate an objectivist-individual teaching approach, including video recordings, computer graphics, and text-based lessons, assignments, and assessments. Eighteen courses (75%) made extensive use of text-based lessons and readings to provide students with information (see Table 4). Some MOOCs were made up of text-based modules specifically designed for online learners with illustrations, simulations, and review questions built into the platform to encourage engagement with course content. An example of this approach would be a course designed by Carnegie Mellon University's Open Learning Initiative, which was

**Table 3**
MOOC course components, according to the Teaching Approach Framework.

| | Objectivist-individual[a] | Objectivist-group[b] | Constructivist-individual[c] | Constructivist-group[d] |
|---|---|---|---|---|
| Hard | | | | |
| Biology 1 | x | | | |
| Biology 2 | x | | | |
| Biology 3 | x | x | | |
| Chemical engineering | x | | | |
| Computer graphics | x | x | x | |
| Engineering | x | | | |
| Medicine | x | x | | |
| Nursing | x | x | x | x |
| Physics | x | x | x | |
| Public health | x | | | |
| Statistics 1 | x | x | | |
| Statistics 2 | x | x | | |
| Soft | | | | |
| Economics | x | x | x | x |
| English composition | x | x | x | x |
| Gaming | x | x | x | |
| Geography | x | | | |
| Health and climate | x | x | x | x |
| Law | x | x | x | x |
| Macroeconomics | x | | x | |
| Philosophy | x | x | x | x |
| Poetry | x | | | |
| Product development | x | x | x | x |
| Social theory | x | | | |
| Sociology | x | x | x | x |

Note: This table illustrates the categorization of individual course components according to the Teaching Approach Framework by Arbaugh and Benbunan-Fich (2006) and not the overall pedagogical structure of each course.

[a] Pedagogical tools in this category include: recorded lectures, textbooks, multiple-choice and single-answer assessments.

[b] Pedagogical tools in this category include: discussion boards with question-and-answer exchange.

[c] Pedagogical tools in this category include: independent activities related to content, discussion board posts, interactive online labs, and links to external online resources.

[d] Pedagogical tools in this category include: peer-reviewed writing assignments, threaded/thematic discussion board dialogue, instructor questions/prompts for discussion, and live video conference/events with instructor.

"designed with learning activities dispersed throughout the content" as well as "self-assessments, in combination with clear learning objectives" that independent learners can use to ensure that they are mastering the material without the help of an instructor or peers (http://oli.cmu.edu/learn-with-oli/get-tips-for-better-learning/). Other courses used open source textbooks, online resources specifically developed for the course, or links to academic content that is freely available on the Internet.

Instructors in 22 courses (92%) utilized video recordings in some way to share information, including PowerPoint slides with voiceover instruction, recordings of the instructor speaking directly into the camera, an animated whiteboard where the instructor could "draw" text and formulas, recordings from a traditional classroom setting, and full animation or use of an avatar (see Table 4). The Open Yale Course in this study, for example, was made up of videos of the instructor lecturing in a traditional classroom, along with a course reading list and some additional resources. The idea is that participants can be a "fly on the wall" in a course taught at one of the most prestigious universities in the world, but there is no opportunity to engage with other students or the instructor directly. Yet, as the following section will illustrate, some MOOCs have incorporated more collaborative elements and new ways to assess learning with the help of advances in computer-mediated technology.

### 5.2. Objectivist-group approach

Although group interaction was not necessarily a requirement for course completion, a number of MOOCs in the sample tried to build collaborative activities into the curriculum to encourage engagement among peers. According to Arbaugh and Benbunan-Fich (2006), "Collaborative activities allow learners greater opportunities for increased social presence and a greater sense of online community, both of which have been associated with positive online course outcomes" (p. 439). Based on the sample, a group-oriented approach was more common in MOOCs that have a specified start and end date. Forty-six% (11) of the MOOCs in this study used a pre-determined timeline for instruction. In these courses, students generally moved through the material at the same time, accessing information as it became available each week and submitting assignments and exams by specific deadlines, all of which lends itself to higher levels of group dialogue and even collaboration.

The objectivist-group approach is still based on a "one-way transmission of objective content from the instructor to the student" but it also "requires the students to work together and cooperate in completing group assignments" (Arbaugh & Benbunan-Fich, 2006, p. 438). Among the courses in the sample, instructors did not incorporate group assignments very often and those that did were not generally using a highly constructivist approach. One pedagogical tool that was used quite frequently to encourage interaction among students was the online discussion board. Discussion boards were present in more than 65% of the sample (see Table 5). Participation varied greatly with some courses having very limited activity, others including only concrete question-and-answer style exchanges between students, and a few enjoying a more constructivist orientation with extensive discussion and threaded conversations between groups of students.

For example, thousands of students have taken one of the statistics courses from the sample since its inception. As an open-access course with no specific start and end date or restrictions for accessing materials, students work through the material alone and can post questions to the discussion board if they need help figuring out a concept or completing a particular assignment. This particular course includes an extensive discussion board with hundreds of topics, but the vast majority of these posts offer limited threaded conversation among students. For example, one topic entitled, "how do you plot graphs using Python," had only 37 posts where students answered this question in various ways but the thread had been viewed more than 25,000

**Table 4**
Mode of instruction.

| | Text/digital textbook | Illustrations; simulations[a] | White board voiceover[b] | Power point slides (PPT) | PPT w/voiceover[c] | Instructor talking to camera[d] | Recorded traditional lecture[e] | Animation/avatar[f] |
|---|---|---|---|---|---|---|---|---|
| Hard | | | | | | | | |
| Biology 1 | x | x | | | | | | |
| Biology 2 | x | x | | | | | | x |
| Biology 3 | | | | | | | x | |
| Chemical engineering | x | | | | x | x | | |
| Computer graphics | x | x | | | x | x | | |
| Engineering | x | x | | | x | | | |
| Medicine | x | | | | x | x | | |
| Nursing | x | | | | x | x | | |
| Physics | | | x | | | x | | |
| Public health | | | | | x | | x | |
| Statistics 1 | x | | | x | | x | | |
| Statistics 2 | | | x | | | x | | |
| *Percentage within group* | *67* | *33* | *17* | *8* | *50* | *58* | *17* | *8* |
| Soft | | | | | | | | |
| Economics | | | | | x | x | | |
| English composition | x | | | | x | x | | |
| Gaming | x | x | | | | | | x |
| Geography | x | x | | | | | | |
| Health and climate | x | | | | x | | | |
| Law | x | x | | x | | x | | |
| Macroeconomics | x | x | | | x | x | | x |
| Philosophy | x | | | x | | | x | |
| Poetry | | | | | | x | | |
| Product development | x | x | | | x | x | | |
| Philosophy | x | | | | | | x | |
| Sociology | x | | | | x | x | | |
| *Percentage within group* | *83* | *42* | *0* | *17* | *50* | *58* | *17* | *17* |
| Percentage of total | 75 | 38 | 8 | 13 | 50 | 58 | 17 | 13 |

[a] Category includes static digital images and interactive digital images. Both were used to help further explain concepts in the curriculum.
[b] Category includes digital whiteboard image with instructor drawing text and images while talking to the student. Instructor's face is generally not visible.
[c] Category includes video capture of PowerPoint slides with voiceover from instructor to help explain concepts.
[d] Category includes video capture of course instructor talking directly into the camera. Often coupled with PowerPoint slides, whiteboard, etc.
[e] Category includes video capture of classroom with instructor lecturing to a room of students. Often includes chalkboard, whiteboard, or other tools.
[f] Category includes use of avatar as instructor, with recorded voiceover, or use of animation/animated figures to teach course concepts.

times. One can imagine that students search and review old posts to help answer their questions as they work independently to complete the MOOC. In this way, the discussion board does not necessarily provide a platform for collaborative group learning in this course. Yet, even in an open course where students are working on the materials independently and only a small percentage of students actively participate in online discussions, the discussion board still appears to be a valuable resource for these independent learners.

### 5.3. Constructivist-individual approach

According to Arbaugh and Benbunan-Fich (2006), the constructivist-individual teaching approach "assumes that students construct their own knowledge independently by actively interacting with the subject matter and combining information from different sources" (p. 438). A number of courses in the sample used instructional methods that encouraged students to interact with course material, consider external sources, and articulate their own understanding of particular topics. Eight of the 24 MOOCs in the sample, or one third, used open-ended, short-response questions in assignments and quizzes (see Tables 6 and 7). Students could generally compare their own response to a computer-generated or static answer key provided by the instructor, but five courses also included open-ended questions without supplying a correct response or explanation. Many courses also encouraged students to utilize external resources, including websites, open access textbooks, reports, and online labs and simulations.

Six MOOCs, or 25% of the sample, incorporated independent activities into course curriculum to encourage students to engage with the material and put their learning in context (see Table 6). Some activities were required while others provided optional practice for students. The instructor in the physics course, for example, asked students to conduct their own experiments including calculating the circumference of the earth by measuring shadows. Although this assignment was not graded, it gave students the opportunity to apply the principles presented by the instructor in a real world setting. Yet, as an optional assignment, it is difficult to know whether or not students actually utilized this activity to deepen their understanding of physics.

Another example was an optional assignment in the nursing course that encouraged students to make a list of all the people that patients in their particular unit interact with each day, and to consider how these health care providers and support staff might coordinate their care in more effective and efficient ways based on the principles introduced in the course. Again, as an optional assignment, students would have to be self-motivated to go above and beyond the requirements of the course to complete this activity but it does offer students a concrete example of how the course principles might affect their professional setting.

### 5.4. Constructivist-group approach

The constructivist-group teaching approach encourages the highest level of collaboration and critical inquiry among participants because "students have to interact with others in the knowledge construction process" (Arbaugh & Benbunan-Fich, 2006, p. 438). While none of the MOOCs in this study utilized this approach for the majority of course activities, one third of the courses incorporated a constructivist-group activity in some way, including peer-reviewed writing assignments, required group activities or debates on the discussion board, and live video conferencing with the instructor (see Table 3).

Instructors in five of the courses posed open-ended questions and required students to submit written responses that were then redistributed

**Table 5**
Mode of interaction among peers and with the instructor.

| | *Student interaction* | | | | *Instructor/TA interaction* | | |
|---|---|---|---|---|---|---|---|
| | Discussion board Q&A[a] | Discussion board dialogue[b] | Discussion prompts[c] | Chat/Study groups[d] | Static posts | Active on discussion board | Synchronous, "live" event[e] |
| Hard | | | | | | | |
| Biology 1 | | | | | | | |
| Biology 2 | | | | | | | |
| Biology 3 | x | | | x | | | |
| Chemical engineering | | | | | | | |
| Computer graphics | x | x | | x | x | x | |
| Engineering | | | | | | | |
| Medicine | x | x | | x | x | | |
| Nursing | | | | | | | |
| Physics | x | | | | x | | |
| Public health | | | | | | | |
| Statistics 1 | x | x | | | x | | |
| Statistics 2 | x | | | x | | x | |
| *Percentage within group* | *50* | *25* | *0* | *33* | *33* | *17* | *0* |
| Soft | | | | | | | |
| Economics | x | x | x | | | x | |
| English composition | x | x | | x | x | | |
| Gaming | x | x | | | | x | |
| Geography | | | | | | | |
| Health and climate | x | x | x | | x | | x |
| Law | x | x | x | x | | x | |
| Macroeconomics | x | | x | | | | |
| Philosophy | x | x | x | | x | x | |
| Poetry | x | | | | | x | |
| Product development | x | x | x | | x | | |
| Philosophy | | | | | | | |
| Sociology | x | x | | | x | | x |
| *Percentage within group* | *83* | *67* | *50* | *17* | *42* | *42* | *17* |
| Percentage of total | 67 | 46 | 25 | 25 | 38 | 29 | 8 |

[a] Category includes courses where discussion board served as a platform for question and answer sessions as opposed to discussion/dialogue among participants.
[b] Category includes courses where discussion board served as a platform for threaded, back-and-forth dialogue among participants.
[c] Category includes courses where instructor posted prompts on the discussion board, students were asked to pose questions for discussion on the boards, etc.
[d] Category includes those courses that offered platform for chat or study groups, student-led study groups, etc. Designation does not equate to significant use by participants.
[e] Category includes synchronous or "live" sessions hosted by instructor/TA such as virtual office hours, webcasts, and Skype chats with select students broadcast for full class.

and reviewed by fellow students. Typically, students who submitted a written response critiqued the writing of a handful of their peers using a grading rubric supplied by the instructor. Students earned points for participation more than substance, and course discussion boards evidenced mixed reviews of the effectiveness of the peer-review process with comments about the helpfulness of feedback, challenges of cultural differences, and uncertainty about assignment parameters.

More than 45% of the MOOCs in this study featured some level of topical student dialogue on discussion boards (see Table 5). Some instructors posted open-ended questions or prompts to spur dialogue, while other courses provided students with a platform to create optional study groups or engage in independent online chat with peers. The instructor of the philosophy course, for example, polled students for their opinion about a particular societal phenomenon and then required students to discuss in groups. One thread arguing against the "effectiveness of torture" included more than 200 comments and extensive dialogue between students about this topic. Yet, this thread was the outlier and the vast majority of discussion prompts garnered limited discussion with only a handful of peer responses or none at all.

A course on human health and climate change provided the best example of a required group activity with a constructivist approach that was incorporated into the course curriculum. In this particular course, students signed up to participate in one of more than 40 "discussion solution groups" (DSG) and then responded to a prompt from the instructor to provide an example of a "best in class" company/organization in that category. Students voted for their favorite responses and the top ten selections moved on to the next round of the activity.

This DSG activity included three rounds of postings and voting that built on each other to engage students in discussion about specific topics of interest. Thousands of students participated in DSGs through each round and voted for their favorite posts at each opportunity. In response to one DSG, a teaching assistant posted a personal comment praising the group for their participation, courtesy, and thoughtful responses, stating that it was "exactly as we envisioned for an interactive student dialogue."

While peer-reviewed assignments can be a highly useful tool in MOOCs to facilitate open-ended writing assignments and engagement with course material, students are still completing these activities independently with limited opportunity for collaboration. Even discussion board assignments where students are required to post a response to a particular prompt from the instructor do not necessarily encourage group collaboration and learning since students generally just respond to the question and do not engage in a robust dialogue on a particular topic. This trend was evident in the criminal law course where the instructor required students to comment on a specific topic each week, such as capital punishment or the insanity defense. Many students completed this course requirement by posting a response but there was minimal follow-up discussion or critical dialogue among participants related to these postings. In the following section, we will discuss the range of pedagogical practices found in the study sample and consider whether or not these teaching methods provide students with a space to connect the lessons to their own lives in meaningful and critical ways.

## 6. Discussion

MOOCs have sparked an intense new debate about the role of technology in shaping higher education. As open online learning spaces, these courses have the potential to open access to new skills and

**Table 6**
Mode of assessment – assignments.

| | Optional | Required | Multiple choice[a] | Open ended[b] | Activity[c] | Discussion board post[d] | External resources[e] |
|---|---|---|---|---|---|---|---|
| Hard | | | | | | | |
| Biology 1 | x | | x | | x | | x |
| Biology 2 | | | | | | | |
| Biology 3 | x | | x | x | | | |
| Chemical engineering | | | | | | | |
| Computer graphics | | x | | x | x | | x |
| Engineering | | | | | | | |
| Medicine | | | | | | | |
| Nursing | | | | | | | |
| Physics | x | | | | x | | x |
| Public health | | | | | | | |
| Statistics 1 | x | x | x | x | | | x |
| Statistics 2 | x | x | x | | x | | |
| *Percentage within group* | *42* | *25* | *33* | *25* | *33* | *0* | *33* |
| Soft | | | | | | | |
| Economics | x | | x | | | x | |
| English composition | x | x | | x | x | x | |
| Gaming | | | | | | | |
| Geography | x | | | | x | | |
| Health and climate | x | x | x | x | | | |
| Law | | | | x | | x | x |
| Macroeconomics | | x | | x | | | x |
| Philosophy | x | | x | | | x | |
| Poetry | x | | | x | | | |
| Product development | | | | x | | x | |
| Philosophy | | | | | | | |
| Sociology | | x | | x | | | |
| *Percentage within group* | *50* | *33* | *25* | *58* | *17* | *42* | *17* |
| Percentage of total | 42 | 29 | 29 | 42 | 25 | 21 | 25 |

[a] Category includes multiple choice questions that offered either computer -generated response or static answer key.
[b] Category includes open-ended questions posed to students. Responses varied, included computer generated answer, static answer key, and no answer/response.
[c] Category includes a wide range of activities that students needed to complete on their own, such as measurements, talking to colleagues, and researching topics.
[d] Category includes students being asked to post comments on the course discussion board, and could include commenting/voting on posts from peers or the instructor.
[e] Category includes assignments that required the use of materials external to the course. Links to external resources may or may not have been included.

knowledge to large numbers of students. Yet, there are inherent challenges in trying to automate instruction for an unlimited audience. Completion rates have been extremely low in MOOCs, averaging 7% according to one report (Parr, 2013), which points to limitations in the design and execution of these courses. Even if many participants have no intention of finishing their course and earning a certificate, a completion rate of less than 10% indicates that many open online courses are not designed to effectively incorporate a "community of inquiry" with the teaching, social and cognitive presence that Garrison et al. (2001) have shown to encourage satisfaction and persistence among participants.

In this study, we examined the epistemological and social dimensions of teaching in open online education, and our findings suggest that the range of pedagogical practices currently used in MOOCs tends toward an objectivist-individual approach. While all of the courses in our sample used elements of this teaching approach, examples of effective constructivist-group approaches were much less common. Discussion boards were available in the majority of courses, but most were used by peers or teaching assistants to explain specific assignments or concepts as opposed to facilitating meaningful collaboration and group-oriented knowledge construction. Instructors in a few of the MOOCs used the boards to supplement their instruction by posting discussion topics, requiring student comments, or incorporating group activities into the curriculum. Results were mixed. The challenge lies in creating a community of learners and facilitating collaborative activities that give students an opportunity to deepen their understanding and learn from each other.

The dominance of the objectivist approach raises questions about the kind of knowledge that is valued in open online education and the current limitations of this platform. Further, those who produce MOOCs are in a privileged position when it comes to deciding what subjects and course content are created and distributed for a mass audience. Open Course Ware initiatives, for example, tend to focus on knowledge and information that can be defined in relatively concrete ways that are more easily assessed through multiple-choice and single-answer tests of comprehension (Rhoads et al., 2013). If the central goal of MOOC instructors and providers is to increase efficiency by making instruction scalable to an unlimited audience, then an objectivist-individual approach would be appropriate and even desirable. But if educators want to broaden access to meaningful learning opportunities and use technology to enhance instructional quality (Korn, 2013) then the simple transfer of knowledge from expert to novice is not enough.

Giroux (2011) argues that the influence of market interests and the notion of corporate time, "accentuates privatized and competitive modes of intellectual activity, largely removed from public obligations and social responsibilities" (chapter 6, para. 17). In this model, job training is prioritized over the development of political agency and social responsibility. Giroux goes on to state that, "shorthand, quantification and measurements become dominant modes of thought" (2011, chapter 6, para. 18). Learners are tasked with digesting specific knowledge that can be easily measured and translated into capital. While the development of transferable skills is valuable, education should also empower students to critically evaluate information and actively participate in social discourse.

One might argue that an objectivist-individual approach is well suited for many science and math courses, which constitute the majority of MOOCs (Educause, 2013). Based on the study sample, MOOCs in the hard sciences were less likely to incorporate constructivist teaching approaches, as compared to those courses in other fields. These findings mirror common themes among different disciplines within academia more broadly. According to Biglan (1973), the hard sciences assume a single paradigm that defines appropriate problems for study and methods to use. Yet, learning is still situated in a particular context

**Table 7**
Mode of assessment — exams and quizzes.

| | Multiple choice | Fill in the blank[a] | Open ended short[b] | Open ended long[c] | Multiple attempts allowed | Certificate of completion[d] | Optional exam for credit[e] |
|---|---|---|---|---|---|---|---|
| Hard | | | | | | | |
| Biology 1 | x | | x | | x | | |
| Biology 2 | x | | | | | | x |
| Biology 3 | x | | x | | x | | |
| Chemical engineering | | | | | | | |
| Computer graphics | | | | | | x | |
| Engineering | x | | x | | x | x | |
| Medicine | x | | | | | x | |
| Nursing | | | | | | | x |
| Physics | x | x | | | | x | |
| Public health | | | | | | | |
| Statistics 1 | x | x | | | | x | |
| Statistics 2 | x | x | | | | x | |
| *Percentage within group* | *67* | *25* | *25* | *0* | *25* | *50* | *17* |
| Soft | | | | | | | |
| Economics | x | | x | | x | x | |
| English composition | | | | x | | x | |
| Gaming | | | x | | | x | |
| Geography | x | | x | | | | x |
| Health and climate | x | | x | | | x | |
| Law | x | | | | x | | |
| Macroeconomics | x | | x | | | x | x |
| Philosophy | x | | | | | x | |
| Poetry | | | | | | | |
| Product development | | | | | | | x |
| Philosophy | | | | | | | |
| Sociology | | | | x | | x | |
| *Percentage within group* | *50* | *0* | *42* | *17* | *17* | *58* | *25* |
| Percentage of total | 58 | 13 | 33 | 8 | 21 | 52 | 21 |

[a] Category includes assessment where students were required to offer a numerical response, often to an equation.
[b] Category includes short-response formats, typically students received computer-generated stock answer to compare, answer key.
[c] Category includes courses that incorporated peer-reviewed essays into student assessment.
[d] Course provider would generate a certificate stating that the study completed the course with a particular grade/percentage.
[e] Category includes courses linked to institutions of higher education with option to enroll for credit; option to sign up for specific exams (ie. CLEP) to earn credit.

and students engage with curriculum based on their lived experiences within their social environment (Lave & Wenger, 1991). A constructivist teaching approach, even in a hard science course, would help students to gain a deeper understanding of the material and build a foundation for more advanced study and mastery (Freeman, Haak, & Wenderoth, 2011; Haak, HilleRisLambers, Pitre, & Freeman, 2011).

Even though the objectivist-individual teaching approach was prevalent within the sample, nearly half of the courses incorporated at least one instructional tool that encouraged participants to construct their own understanding of course content through self-reflection, activities that link curriculum to real world settings, or interaction with fellow learners. According to Arbaugh and Benbunan-Fich (2006), students benefit from active, collaborative teaching approaches because they prioritize interaction between the learners themselves and situate students at the center of the knowledge construction process. Individuals learn in the context of their social and cultural environment (Lave & Wenger, 1991), and their learning is maximized when they interact with peers, educators, and experts (Vygotsky, 1978). While there is great value in independent learning, social learning encourages students to articulate their own beliefs and experiences, listen to the opinions of others, and find consensus in divergent viewpoints.

One of the major challenges for MOOC instructors is to break away from the traditional "sage on a stage" model of teaching that is prevalent in both traditional and online learning environments, and further opportunities for interaction and engagement between students and the instructor. As the literature discussed, students in online learning environments benefit from meaningful contact with their instructor (Eom et al., 2006; Swan, 2001). At present, most students who complete a MOOC have already earned a college degree (Kolowich, 2013) and are more likely to be comfortable in an academic setting. Therefore, increasing access to education through participation in MOOCs will require careful attention to pedagogical practices that support a wide range of students and create engaging and inclusive dialogue and collaboration. Otherwise, MOOCs run the risk of merely replicating the flawed system of large, lecture-style courses prevalent in public institutions that do little to encourage student persistence and achievement.

Finally, advocates argue that MOOCs are leveraging technology to "transform" and "disrupt" higher education, and create a "revolution" within a struggling system. Instead of settling for the status quo, MOOCs have the potential to open up knowledge to students around the world. Yet, at present, the major providers are developing open online courses that mimic traditional face-to-face courses with a focus on measurable learning outcomes that will translate into course credit at a variety of institutions. While this effort may help MOOC providers reach their goal of accessing coveted revenue streams within higher education, it also has the potential to stifle creativity among instructors and developers.

The original MOOC led by Siemens and Downes in 2008 was based on the idea that technology can be used to create an online community where students engage in the learning process by remixing and repurposing information according to their own interests and experiences. MOOCs that follow this model of a connectivist learning community focus on bringing together a network of individuals interested in working together to navigate and critically examine information around a particular topic and further the discourse with their own ideas and reflections. Many of the MOOCs being produced and distributed in recent years by private companies and elite universities bear little resemblance to this model of teaching and learning. While we are not arguing that all MOOCs should abandon structured curriculum and grading systems, it is important that instructors and developers not lose sight of the origins

of these innovative online courses and their potential to create dynamic communities of inquiry. MOOCs have grown out of the idea that technology can help educators to create social learning environments that defy space and time, and one can only hope that technologists will continue to push the boundaries of innovation for the sake of building community and engagement instead of focusing on profit margins.

## 7. Conclusion

This study raises some important concerns about the degree to which MOOCs are actually revolutionizing higher learning, given the tendency for the pedagogical strategies of MOOC instructors to be tied to objectivist views of knowledge. Relying primarily on one-directional relationships between instructor-based knowledge and students as recipients, as both constructivist theories and critical pedagogy highlight, is hardly conducive to the transformative forms of engaged learning seen as most valuable to encouraging both active learning and active democratic citizenship. Thus, if MOOCs are to achieve the revolutionary potential often claimed, advocates may want to reflect upon the origins of the movement and focus on developing and incorporating more creative and empowering forms of open online learning.

## Appendix A. Listing of MOOC providers and platforms included in the study

| Platform or provider | Website |
|---|---|
| Canvas Network | canvas.net |
| Coursera | coursera.org |
| Education Portal | education-portal.com |
| edX | edx.org |
| Faculty Project/Udemy | facultyproject.org |
| MR University | mruniversity.com |
| NovaEd | novoed.com |
| MIT Open Course Ware Scholar | ocw.mit.edu/courses/ocw-scholar |
| Carnegie Mellon University Open Learning Initiative | oli.cmu.edu |
| Open Michigan | open.umich.edu |
| OpenLearning | openlearning.com |
| Open Yale Courses | oyc.yale.edu |
| Saylor.org/Saylor University | saylor.org |
| Safia Project | safia.fhda.edu |
| Udacity | udacity.com |
| Webcast Berkeley | webcast.berkeley.edu |

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# Designing a role structure to engage students in computer-supported collaborative learning

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ABSTRACT

This study investigates the design of a role structure to engage undergraduate students in collaborative knowledge construction. A total of 72 students of an Instructional Design course were divided into 12 small groups, among which six roles of Starter, Supporter, Arguer, Questioner, Challenger, and Timer were assigned respectively. Group discussions of eight learning themes were recorded, which included approximately 1500 lines of messages. Taking group discussion as the unit of analysis, a two-dimensional coding scheme was developed to discover the extent to which the designed role structure facilitated the modeling of the group cognitive processes. The findings suggest that the role structure design supports the students in collaborative problem solving by modeling the joint collaborative activities and group cognitive processes. Therefore, mapping the designed roles of related cognitive components in a group discussion may develop group cognition in a collective problem-solving process.

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## 1. Introduction

Many learning science researchers have taken an interest in collaborative learning over the last two decades, guided by the belief that students must develop the ability to establish mutual understanding and gain new knowledge through the process of problem-solving in collaboration with their peers (Hogan, 1999; Scardamalia, Bereiter, & Lamon, 1994; Yu, 2004). Effective collaboration requires positive interdependence and individual accountability of each group member (Johnson & Johnson, 1989). However, placing students in groups does not necessarily lead to improved understanding and performance within a collaborative knowledge construction context (Karakostas & Demetriadis, 2011; Weinberger, Reiserer, Ertl, Fischer, & Mandl, 2005). This phenomenon may be due to the lack of a diffusion of engagement in groups and responsibility for the joint tasks (Morris et al., 2010). Effective collaboration requires an environment that promotes positive interdependence and individual accountability, thereby ensuring that all members contribute to the meaning-making process.

In facilitating collaborative learning, computer-supported collaborative learning (CSCL) systems may serve as tools to support the building of shared knowledge and negotiation of such knowledge (Stahl, 2003). To address the issue of interdependence and individual accountability in collaborative learning, role-assigning methods are frequently suggested as a means of structuring CSCL design (De Wever, Van Keer, Schellens & Valcke, 2009; De Wever, Keer, Schellens, & Valcke, 2010; Schellens, Van Keer, De Wever, & Valcke, 2007; Strijbos & Weinberger, 2010). The underlying assumption is that interdependencies and individual accountability can be promoted and enhanced through the proper division of labor. Therefore, structure design has become a research focus in the field of CSCL (Kapur & Kinzer, 2008), within which the role-structuring process is typically realized by assigning a student with a stated responsibility. Such responsibility consists of multiple activities, thus forming a pattern of acts normally performed by a specific group member (Spada, 2010; Strijbos & De Laat, 2010).

Based on an undergraduate Instructional Design course offered in a Chinese university, the current paper examines how a role structure design models the group cognitive processes of collaborative learning to engage students in this learning process. This course consists of a series of CSCL units and weekly face-to-face classroom sessions. The major challenge faced by tutors in this course is student engagement: not all students are fully engaged in the course activities, especially when the course is delivered using CSCL. Here, roles are assigned to the students to better engage them in group interactions and help them achieve high-quality collaboration. Therefore, the main research question of the current study is as follows: How and to what extent can the designed role structure model the joint cognitive process for the students to engage in CSCL? The sub-research questions are given below.

- How and to what extent do students enact the assigned roles?
- How and to what degree do the designed roles support students in

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group cognitive processes?
- How and to what degree do the designed roles model the group cognitive process to engage students in collaborative problem solving?

Although there are a number of studies on role assignment in the CSCL context, most of these are focused on the effects of roles on participation rates (Seo, 2007), interaction patterns (Morris et al., 2010; Strijbos et al., 2004), and knowledge construction levels (Schellens et al., 2007). The current study intends to engage students in a collaborative learning process by designing roles to model the joint cognitive process. This problem has remained a challenge for students when the cognitive process takes place at the group level (Stahl, 2006). Roles are structured and assigned with the specific aim of modeling the group cognitive process so as to condition students to actively participate in the meaning-making process.

## 2. Literature review

As an emerging topic in CSCL research, the use of roles (i.e., stated functions and responsibilities that guide individual behavior and regulate group interaction) aims to facilitate group learning (Strijbos & De Laat, 2010) by promoting individual accountability and positive interdependence. These objectives constitute the core of collaborative learning. Furthermore, scholars have developed the emerging view of considering groups as information processors in the development of group cognition (Hinsz, Tindale, & Vollrath, 1997; Stahl, 2006). In this approach, interaction among members is the key mediator facilitating the co-construction of shared understanding and the creation of new knowledge as a group. Through this discourse, knowledge or ideas are constructed, negotiated, and created (Lamon, Reeve, & Scaredamalia, 2001). To shift the focus of discourse toward knowledge creation and co-construction, rather than knowledge sharing in a group activity, learners are usually encouraged to produce cognitive artifacts, such as interpreting or reasoning their ideas. This process involves critically reflecting upon the contributions of other group members and building on one another's ideas. However, a new learning approach and high cognitive engagement lead to complexity, which may hinder the development of group cognition. In response, role assignment may reduce such complexity and facilitate group cognition development because, using this approach, learners can maximize their participation based on their assigned roles.

### 2.1. Roles in participative stance

Studies on group dynamics reveal that "individual accountability" and "positive interdependence" are important factors that ensure the smooth functioning of any group, and therefore, to the principles of the CSCL approach (Forsyth, 1999; Strijbos, Martens, Jochems, & Broers, 2007). Individual accountability refers to the extent to which students are individually accountable for joint tasks or duties, whereas positive interdependence is the degree to which the performance of a single group member depends on the performance of other members. Assigning roles for different group members can improve coordination and promote group cohesion and interdependence (Brush, 1998; De Wever, Schellens, Van Keer, & Valcke, 2008). Research in this area reveals that the positive effects of role assignment foster positive interdependence and individual accountability. These effects include helping students focus on their responsibilities in the group and on the quality of their contributions, thus raising group performance awareness among group members; stimulating individual contributions (Strijbos et al., 2004, 2007); ensuring organized division of tasks, coordination and integration; and alleviating problems related to non-participation or domination of interaction by one group member (Cohen, 1994; Strijbos & De Laat, 2010).

Roles can be classified based on different perspectives, such as functional versus cognitive roles (Palincsar & Herrenkohl, 2002; Strijbos et al., 2007), product versus process roles (Strijbos & De Laat, 2010), and other dimensions, such as group size and efforts invested by the different roles (Pfister & Oehl 2009, Strijbos & Weinberger, 2010).

Functional roles focus on supporting the "doing" of a task by classifying and assigning particular functions, whereas cognitive roles support the "thinking" of the task by classifying and assigning relevant types of cognitive engagement required in performing the designated roles (Morris et al., 2010). Classic functional roles include data collector, recorder/note taker, or editor (Slavin, 1995). For example, in the studies of Strijbos et al. (2004, 2007), the roles of project planner, communicator, editor, and data collector are assigned with task-oriented functions, resulting in improved coordination and overall group efficiency. By contrast, the roles of feedback provider, summarizer, theoretician, and process reflector are typically aimed toward cognitive engagement (De Wever et al., 2010; Schellens et al., 2007).

Roles are originally used to structure group processes, which are mainly product- or process-oriented or the combination of both (Strijbos & De Laat, 2010). Typical examples of product roles are the starter and wrapper, who initiate and summarize the online discussion tasks (Hara, Bonk, & Angeli, 2000), respectively, as well as the explainer and listener who are the ones designated to support the task outcomes (Ertl, Fischer, & Mandl, 2006). On the contrary, process roles are used to manage the task activities; therefore, participants who take such roles often act as project planner, communicator, and task manager (De Laat & Lally, 2005; Strijbos et al., 2004, 2007). More commonly, the combined roles of both process and product orientation can be used to facilitate the online collaboration process, through which participants can remain focused on the issues discussed as they participate and proceed with the tasks (De Wever, Van Keer, Schellens, & Valcke, 2007; Pilkington & Kuminek, 2004; Strijbos et al., 2004, 2007). In general, roles are based on the participative stance of each individual, either in the product or process of collaboration. When taking group cognition as the unit of analysis, the emphasis is on the cognitive process of *a group*, of which roles are components of the process and are rarely scripted as independent components.

### 2.2. Roles in the group cognitive process

In an in-depth review of group information processing, Hinsz et al. (1997) suggest that the processes involved in group task performance represents the combination of two domains, namely, individual contributions based on individual participative stance, and the integration of the contributions in the production of group-level outcomes. Damart (2008) has indirectly shown the importance of role structure in group-level cognitive processes. Individual cognitive involvement in a collaborative effort is the basis for group cognition, which integrates individual cognitive processes to produce a collective product, thus implying that better group cognition is achieved if participants are better able to perform the roles meant to cover the functions of a cognitive process. By integrating the concept of "organizing participation" (P506), Damart (2008) has applied a cognitive mapping technique to organize how participants interact in a problem-solving activity. Interaction is a structured process, which entails performing different cognitive roles of exploring thematic areas, identifying actions, assessing actions, prioritizing actions, and choosing actions. However, that study (Damart, 2008) focused on the methods and tools of the collective problem-structuring process and not on group cognition as the unit of analysis.

By distinguishing dialogue from interaction, Wegerif (2013) proposed looking at dialogues from the inside, thus revealing a new window through which the interaction and the group cognitive process can be examined. The internal view (i.e., the group is a dialogic space) assumes that meaning emerges from the interplay of different perspectives. These perspectives have been suggested in more detail by Stahl

(2006), who considered group cognition as an intersubjective activity performed by acts of interaction to propose, negotiate, display, and define what should count as the salient features of the setting, occasion, and the social norms. Therefore, the group cognitive process is a social meaning-making practice, wherein individual minds may have different roles in establishing and interpreting an established meaning. According to Stahl (2007), the group cognitive process can be approximated to the contributions of threading, uptake, continuity, repair, reference and citation, from which the co-construction of meaning and how people understand one another can be perceived.

In the present research, discourses of roles at both individual and group levels are investigated to identify the interdependence and individual accountability as well as the development of group cognition.

## 3. Research setting and methods

### 3.1. Designing the role structure

The current study focused on the introduction of a scripted role structure as a cognitive process model to engage students to actively participate in CSCL. The role structure consisted of a set of defined roles, their particular functions, and the related prompts describing how these roles can be performed. In this structure, roles were designed from the perspective of modeling the joint cognitive process by combining functional and cognitive engagement. The introduction of roles was based on examples found in previous studies (Cohen, 1994; Shotsberger, 1997) as well as on the specific purpose of discussion tasks with the aim of urging students to participate in discussions. In our study, functional and cognitive roles as well as product and process roles were considered for role selection. On this basis, six roles were developed, namely, Starter, Supporter, Arguer, Questioner, Challenger, and Timer. The functions or responsibilities of the six roles are supposed to offer the cognitive engagement required by a collaborative discussion, from the point of collaborative problem solving. In the design, each role was given clearly defined cognitive functions along with prompts on performing the particular functions to help the students finish the particular cognitive process while participating in the assigned task. The roles and their definitions, the responsibilities that each role should undertake, as well as the respective prompts, are all shown in Table 1.

Prompts were intentionally designed to provide hints, suggestions, and reminders to help users effectively enact a role in a discussion (Table 1). To some degree, these prompts can also be taken as openers or reminding words, which can help students complete specific thinking tasks and cognitive strategies. For instance, "I am not so sure about it because..." is a prompt for a "*challenger*" to question someone else, which can model the particular cognitive process of *challenging* by scaffolding the assigned role to think in an appropriate way.

Although the prompts for each role were designed based on particular cognitive functions, different levels of knowledge construction were also reflected in the prompts. For example, in the prompts for the "Challenger," different levels of cognitive involvement—from simply disagreeing to persuading others—were designed to help students engage in the cognitive process. In fact, "prompts" were found to be useful based on the student feedback that it provided benefits for role fitting. With these "prompts," students felt that they weakened the everyday figure of their peers, thus fostering a thinking good habit with which they were better able to understand their roles. The prompts only worked at the beginning of the study, after which such scaffolding faded out along with the progress of the discussion.

An online system was used to present the course content and disseminate the requirements of the design project and the subtasks. This online system was regarded as a space for each group to present their products and share their discussion results. An open source asynchronous discussion tool called "Interloc" was incorporated into the online environment to introduce the designed roles in the three-week trial session. In the Interloc, the roles were scripted for students within groups and were meant to be adopted in their group talk. For each adopted role, related prompts could be accessed to help the student learn the particular responsibilities entailed by such role, along with the related logical thinking point that should be assumed. After three weeks of familiarizing themselves with their specific roles using "Interloc," students were allowed to move their group discussion to a more commonly used synchronous discussion tool (i.e., "QQ"). QQ is a widely used synchronous chat tool similar to "Interloc." The reason for selecting "QQ" as the replacement tool was that it allowed students to discuss in their native language (Chinese), because the English language used in "Interloc" posed obstacles that prevented Chinese students from fully expressing their ideas. The roles were similarly scripted in "QQ" as in "Interloc."

At the start of the study, the roles were randomly assigned to six students in each group. When the students gradually became familiar with the responsibilities of their roles and the associated prompts, they were able to perform other roles in a discussion when necessary.

**Table 1**
The design of the role structure.

| Roles | Function description | Prompts |
|---|---|---|
| Starter | To kick off the discussion, put forward a preliminary analysis of the task, add new points for peers to build upon, and give new impulses when discussion slacks off. Also make a summary in certain time, and to promote the further development of the collaboration. | To begin with, I think<br>We can firstly make sure<br>Let's come to the point<br>Let me say more about that<br>From the story, it's clear that<br>Let's solve the problems, now |
| Supporter | To support peers' ideas by making positive feedback with reasonable evidence. | I agree because<br>That's right<br>I can see what you are saying<br>An example is<br>I have read that |
| Arguer | To make further explanation/reasoning to the statement/idea that is made by peers, with logical and critical thinking. | That is valid if<br>I think both are right because<br>To summarize<br>From the discussion, we can see<br>So what you mean is<br>It sounds great since |
| Questioner | To raise questions from peers' statements, not doubt but ask questions so as to promote discussion. | Why is it?<br>What do you mean when you say?<br>Can you say more on that?<br>Is there another way of looking at it?<br>Where did you read/hear that? |
| Challenger | To challenge peers' statements/ideas, give negative feedback by asking critical questions and probing into their opinions, so as to lead teams to consider the problem critically and logically. | I disagree/am not so sure because<br>Why do you say that?<br>Please give a reason<br>Is there any evidence?<br>But can we trust that?<br>An argument against that is/another view might be<br>I think something different<br>Is it the case that? |
| Timer | To coordinate and moderate the speed of discussion, set the tone for discussion, respond to individual posts, prompt individuals or the group to pursue ideas. | Would you please?<br>Can we?<br>Sorry<br>Ok. Let's move on<br>Would you please? |

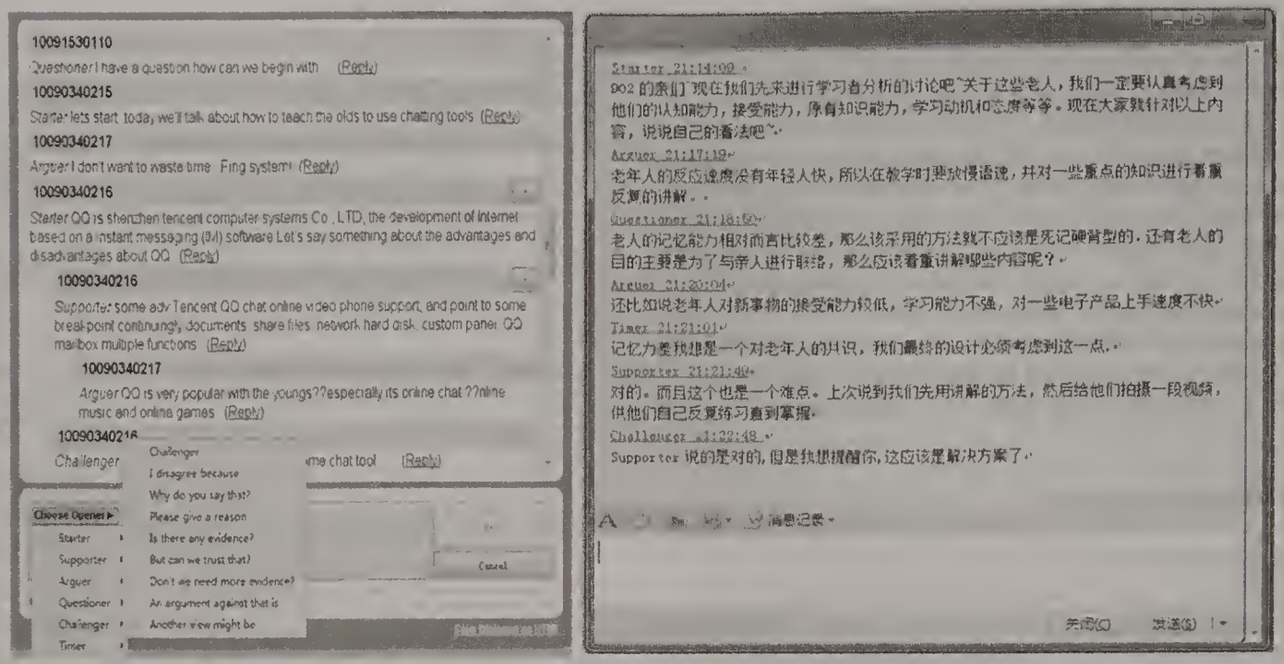
10091530110
Questioner I have a question how can we begin with (Reply)
10090340215
Starter lets start toda, we'll talk about how to teach the olds to use chating tools (Reply)
10090340217
Arguer I dont want to waste time Fing system (Reply)
10090340216
Starter QQ is shenzhen tencent computer systems Co., LTD, the development of internet based on a instant messaging (IM) software Let's say something about the advantages and disadvantages about QQ (Reply)
10090340216
Supporter some adv Tencent QQ chat online video phone support, and point to some break-point continung, documents share files network hard disk, custom paner QQ mailbox multiple functions (Reply)
10090340217
Arguer QQ is very popular with the youngs??especially its online chat ??nline music and online games (Reply)
Challenger
Challenger
I disagree because
Why do you say that?
Please give a reason
Is there any evidence?
But can we trust that?
Don't we need more evidence?
An argument against that is
Another view might be
Choose Opener
Starter
Supporter
Arguer
Questioner
Challenger
Timer
Starter 21:14:09
902 的亲们 现在我们先来进行学习者分析的讨论吧~关于这些老人，我们一定要认真考虑到他们的认知能力，接受能力，原有知识能力，学习动机和态度等等。现在大家就针对以上内容，说说自己的看法吧~
Arguer 21:17:19
老年人的反应速度没有年轻人快，所以在教学时要放慢语速，并对一些重点的知识进行着重反复的讲解。
Questioner 21:18:02
老人的记忆能力相对而言比较差，那么该采用的方法就不应该是死记硬背型的，还有老人的目的主要是为了与亲人进行联络，那么应该着重讲解哪些内容呢？
Arguer 21:20:04
还比如说老年人对新事物的接受能力较低，学习能力不强，对一些电子产品上手速度不快。
Timer 21:21:01
记忆力差我想是一个对老年人的共识，我们最终的设计必须考虑到这一点。
Supporter 21:21:48
对的。而且这个也是一个难点。上次说到我们先用讲解的方法，然后给他们拍摄一段视频，供他们自己反复练习直到掌握。
Challenger 21:22:48
Supporter 说的是对的，但是我想提醒你，这应该是解决方案了。
消息记录
关闭(C)
发送(S)

**Fig. 1.** The screen of dialogue in InterLoc (left) and QQ (right).

When a message was posted to the group discussion, the label of a student role would appear above his/her message (Fig. 1).

### 3.2. Context and participants

The introduction of the role structure to engage students in CSCL by modeling the joint cognitive process was investigated in a research-based higher education setting in a 3rd year Instructional Design course from an e-learning program. The students were familiar with e-learning and often applied software for informal discussion. This course introduces students to the conceptual framework and basic processes related to instructional design. An authentic design project with step by step sub-tasks was assigned to groups of six students (N = 72) in the weekly classroom sessions to promote their understanding and incorporation of the learning content. After a trial session of three weeks, in which the role structure was introduced and adopted, students participated in eight successive discussion themes toward the sub-tasks of the design project parallel to the classroom sessions.

For the current study, the main data source was the record of the group discussion for the eight themes of the design project, which contained approximately 1500 messages.

### 3.3. Data collection and analysis

The coding scheme used in this study focused on group discourse as the unit of analysis, with the aim of identifying the group processes modeled with the role structure. A two-dimensional data coding scheme was developed by taking *group* as the unit of analysis (Wise et al., 2010; Strijbos & Stahl, 2007), where the "function" and "cognition" functions were used separately. The "function" dimension referred to the scripted roles. The responsibility of each role and the different levels of assuming this responsibility were identified to determine the extent to which the students enacted the assigned roles in collaboration. A four-point scale was used to rate each unit of message posted by a particular role. Rating levels for each role of Starter, Supporter, Arguer, Questioner, and Challenger are listed in Table 2.

The "cognition" dimension concerns the group cognitive process, in which the meaning-making process at the group level is used (Stahl, 2006). This group cognitive process used in the current study was developed by referring to the preconditions for joint meaning-making to accomplish group cognitive tasks (Stahl, 2007), in combination with problem-solving constructs. The features of the meaning-making process thus included the following components: Interpreting the problem, Identifying/Sharing/Comparing relevant information, Developing solutions/Providing evidence/reason for solutions, Creating alternative solutions, Negotiating inconsistency, and Making claims/Conclusions/Knowledge. The same units of discourse

**Table 2**
Rating levels of particular role for 'function'.

| Role | Code & level | Level of statements |
|---|---|---|
| Starter | 1–0 | No hit-the point new idea |
| | 1–1 | New idea addressed without explanation |
| | 1–2 | New idea addressed with clarification and leading further discussion |
| | 1–3 | New idea addressed according to the context and leading to final solution |
| Supporter | 2–0 | No response |
| | 2–1 | Simply agree without explanation |
| | 2–2 | Agree with some statements to support his own view |
| | 2–3 | Agree by analyzing and comparing different statements |
| Arguer | 3–0 | No induction |
| | 3–1 | Reasoning with some simple personal points |
| | 3–2 | Reasoning with analysis and arguments to support personal view |
| | 3–3 | Reasoning with logic inference such as cause and effect analysis. |
| Questioner | 4–0 | No questions |
| | 4–1 | Simple questions |
| | 4–2 | Question for specific participant to scaffold further discussion |
| | 4–3 | Question raised to inspire thinking in depth toward a single topic for all participants |
| Challenger | 5–0 | Not challenging |
| | 5–1 | Show his doubts to the view with single question but no clarification raised |
| | 5–2 | Negative doubts with arguments and state his own view |
| | 5–3 | Raise doubts by clear arguments and lead others to think about questions in a critical way. |
| Timer | 6–0 | No time control |
| | 6–1 | Remind the group to slow down or speed up by timer |
| | 6–2 | Remind participants to pace the discussion according to the rate of progress and stop the arguments when it causes a conflict |
| | 6–3 | Have an overview of the discussion in mind to remind participants the rate of progress with some skills of summarizing |

were coded by the dimensions of "function" and "cognition," although a unit may receive a *no code* in "cognition."

The first step of the coding process involved screening the original data. Data were reduced by eliminating off-topic messages, such as greeting words. The message line was used as the coding unit mainly because only one theme was included in each line, which was also observed by Strijbos and Stahl (2007). The units were then pooled together and entered into an Excel file for easy coding and sorting.

The pooled units were coded by four research assistants in accordance with the abovementioned coding scheme. Before the assistants started coding, they went through approximately 5 h of training to understand the coding scheme and the coding process, and to enable them to carry out the coding practice in two pairs. After several rounds of training, coders finally gained mastery of the coding methods. The "ATLAS" software with some statistic functions was applied for coding against the coding units. Further adjustments on the first coding results were also conducted. For example, if three out of four raters had different opinions on the functional coding of one message unit, the raters would be asked to convene and arrive at an agreement after discussion. An inter-rater reliability (IRR) percentage was used because of the complexity of coding. IRR values of 0.8 and 0.806 (Cohen's kappa) were obtained for the "function" and the "cognition" dimensions, respectively. The final units and their coding results were encoded into an Excel sheet for sorting and comparing. For example, to discover and articulate themes within the coded pools, all coded units of a particular role were collected into one file, together with the number of messages posted by this role. This procedure aimed to discover whether a student assigned to a specific role was dutifully performing his/her responsibility. In addition, all coded units were sorted against a particular cognitive component to determine whether a student could assume his/her role accountability, which was modeled as that in the joint cognitive stance.

Furthermore, the coded units from the function dimension were compared with those from the cognition dimension to reconstruct the group discourse structure, and to examine whether the assigned roles were helpful in modeling the cognitive process in the group level. A sample unit and coding can be found in Table 3. In this sample, the message of the "Starter" was rated as the function of the "Starter" to initiate a discussion exactly as expected, whereas the message of the "Timer" was rated as the function of the "Questioner" to raise a question other than that expected for the role of "Timer."

## 4. Findings and discussion

### 4.1. Enactment of assigned roles

The descriptive result of the extent to which each role has been enacted by the students is presented in Table 4. This was achieved by pooling all the coded units against a particular role and judging the function level exhibited by the role. In addition to the means, standard deviations and other descriptive data of enacted levels of roles, a capability of acting the assigned roles (COA) score and a participation degree (PD) score for each role were also analyzed. This step was performed to estimate how the students enacted the assigned roles, along with the degree of role fitting that emerged in the group activities. In the current study, COA referred to the proportion between the amount of messages under the assigned role and the total messages that the said student had ever posted. COA can be used to reveal whether a student with a particular role had been consistently performing his/her responsibility. The PD was calculated using the proportion of the amount of messages of a certain role against the total messages in a group discussion unit.

**Table 4**
Descriptive result of the enacted roles.

| Roles | N | Mean | SD | Std. error | Min | Max | COA | PD |
|---|---|---|---|---|---|---|---|---|
| Starter | 12 | 2.2025 | .18545 | .05353 | 1.80 | 2.50 | 30.96% | 29.61% |
| Supporter | 12 | 1.3810 | .24493 | .07070 | 1.15 | 1.92 | 64.52% | 11.79% |
| Arguer | 12 | 1.6087 | .16937 | .04889 | 1.36 | 1.87 | 42.06% | 11.96% |
| Questioner | 12 | 1.8781 | .39420 | .11380 | 1.40 | 3.00 | 21.81% | 14.24% |
| Challenger | 12 | 1.7111 | .23917 | .06904 | 1.29 | 2.11 | 27.30% | 14.76% |
| Timer | 12 | 1.6058 | .24436 | .07054 | 1.25 | 2.00 | 25.94% | 17.63% |

Among the four rating levels of each role, level 1 was selected as the subjective breakdown point for a one-sample T-test. Based on the T-test results and the descriptive results in Table 4, the six designed roles showed better performance ($P = 0.000$) compared with level 1, suggesting that the individual participative stance of each role was understood and performed well. On the contrary, the results in Table 4 showed that these roles were not evenly enacted. The functions of the "Starter" role (i.e., to initiate a discussion topic) was enacted most effectively, whereas that of the "Supporter" (i.e., to give positive feedback) was enacted with the lowest level of achievement. On the basis of paired comparisons among the six roles, an ANOVA test ($F = 14.476$, $P = 0.000$) revealed that the performance of the six roles were significantly different. The post hoc comparison verified that the function of the "Starter" to initiate a topic was significantly performed better by some students compared with others.

Moreover, the results of COA and PD in Table 4 can also be used to reveal the extent to which the students fulfilled the assigned roles. Based on the descriptive statistics of the COA, the "Supporter" role obtained the highest COA score among the six roles, thus revealing that the "Supporter" performed his/her responsibility most of time when he/she posted messages. However, the PD result showed that the "Supporter" was not very active. On the contrary, the "Starter" role obtained the highest PD score among the six roles, indicating that the "Starter" was the most active participant in the collaboration process. This result echoes the results of the ANOVA test, which showed that the "Starter" role was the best role enacted. Therefore, the "Starters" maximized their participation based on their assigned roles. Meanwhile, no significant differences were found among other assigned roles.

### 4.2. Assigned roles and engagement: modeling of joint activities

The degree to which the role structure models the joint activities to engage students in collaboration can be acquired from the PD statistic as well as the cross-tabulation of the assumed roles and their respective functions. Except for the most active role of the "Starter," no significant difference was observed among the five remaining function types, based on an ANOVA test of the participation of students in the joint activities ($F = 2.462$, $P = 0.056 > 0.05$) (Table 4). The PD was calculated using the amount of messages of a certain role compared with the total messages in a group discussion unit. Hence, the approximated even

**Table 3**
Sample of coding scheme, coding units and coding results.

| Role | Coding unit | Function | Cognition |
|---|---|---|---|
| Starter | Let's discuss 'learner analyses' now. Most potential learners are the elderly older than 50. We should take their cognitive ability, learning style, original knowledge base and so on into consideration. | Starter level 3 | IP (interpret the problem) |
| Arguer | Yes, the old is quite different from the young, they are not good at learning new things. So teachers should slow down the speed of teaching, and be patient to teach them hand by hand. | Arguer level 2 | ISCI (identifying information) |
| Timer | What do you mean "hand by hand"? | Questioner level 1 | No |

**Table 5**
Crosstab of roles' contributions and functions.

| Roles / Functions | Starter | Supporter | Arguer | Questioner | Challenger | Timer | Total |
|---|---|---|---|---|---|---|---|
| 1 | 70.75% | 6.48% | 4.95% | 5.19% | 5.41% | 7.22% | 100% |
| 2 | 17.21% | 26.06% | 13.27% | 15.71% | 11.02% | 16.73% | 100% |
| 3 | 25.37% | 11.95% | 18.77% | 13.42% | 16.26% | 14.23% | 100% |
| 4 | 22.69% | 7.94% | 7.60% | 25.08% | 21.55% | 15.13% | 100% |
| 5 | 18.42% | 7.24% | 14.91% | 12.72% | 30.26% | 16.44% | 100% |
| 6 | 33.87% | 3.04% | 3.37% | 3.88% | 5.63% | 50.22% | 100% |

Function 1–6: kick-off, make positive feedback, make critical further explanation, raise question, probe into opinions, and coordinate.

distribution of PD indicates that the scripted roles are helpful for modeling the group activity to engage students in collaboration.

The assigned roles were helpful in carrying out their respective duties (Table 5). For example, the biggest contributor to the function of the "Starter" role to start a discussion was the role of "Starter" (by 70.75%), whereas about 30% of this function was contributed by other roles. In addition, the role of "Supporter" contributed the largest portion of the function of "giving positive feedback," whereas the role of "Challenger" contributed the most to the function of "probing into opinions," along with the roles of "Questioner" and "Timer." Although most of the "arguing work," or making critical explanations was contributed by the "Starter," the "Arguer" still contributed the second largest portion of this task. Therefore, students were responsible for most core tasks and core functions that were expected for their assigned roles. The results also prove that all students contribute to the meaning-making process, and that collaboration promotes positive interdependence and individual accountability.

### *4.3. Assigned roles and engagement: modeling of group cognitive process*

The descriptive statistics of the coding result for the "cognition" dimension are shown in Table 6. The data were obtained by calculating the percentage of the frequency of each cognition dimension in a group discourse unit.

As a method of intervention of modeling the group cognitive process to engage students in collaborative problem solving, the ideal expected distributions of the six components of cognitive participation must be evenly assigned. Here, we assumed that all students performed the responsibility of their assigned roles and contributed 100% to group cognition by strictly performing their assigned roles during the discussion. A goodness-of-fit test revealed that the data fit the evenly distributed model (each component weighed a proportion of 16.67%) as well as the expected values (Chi-square = 7.274, $P = 0.296 > 0.05$).

The results of the comparison of the coding from the function and cognition dimensions are presented in Table 7. Within a group cognitive process unit, the first three active contributors (above 75% in total) covered all six roles, indicating that all the students were actively involved in the group cognitive process. Given the fact that non-participation was previously a common problem in collaborative learning, this result could indicate that the scripted roles were helpful in engaging students in collaborative problem solving.

Table 7 could be used to reconstruct the group discourse structure and better design the role structure. Taking the joint problem-solving process as an analysis unit (see the excerpt in the following box), the

**Table 6**
Descriptive statistics of cognitive coding result.

| Cognitive unit | IP | ISCI | DS | AS | NS | MC | NO |
|---|---|---|---|---|---|---|---|
| Average | 9.53% | 11.00% | 21.95% | 10.06% | 24.75% | 11.33% | 11.39% |

IP, Interpret the problem; ISCI, Identifying/sharing/comparing relevant information; DS, Developing solutions/providing evidence/reason for solutions; AS, Alternative solutions; NS, Negotiation of inconsistency; MC, Making claim/conclusion/knowledge.

**Table 7**
Roles that contributed to cognitive process.

| Role / Unit | The most frequent contributor | The second most frequent contributor | The third most frequent contributor | Percentage of contribution |
|---|---|---|---|---|
| IP | Starter | Challenger | | 100% |
| ISCI | Supporter | Arguer | Timer | 78.3% |
| DS | Timer | Starter | Challenger | 78.2% |
| AS | Starter | Timer | Questioner | 77.5% |
| NS | Timer | Questioner | Challenger | 76.7% |
| MC | Starter | Supporter | | 90.9% |

cognitive component of interpreting the problem could be initiated by the "Starter" and challenged by the "Challenger" to think twice. The second process was jointly performed by the "Supporter" and the "Arguer" to achieve the tasks of identifying, sharing, or comparing information positively and critically. Developing a solution was performed by the "Timer" and initiated by "thinking twice" in response to questions that were raised with the aim of thinking an alternative solution once again. To negotiate about the disagreement, the perspectives of the "Questioner," "Challenger," and "Timer" should be involved. Finally, the conclusion was made by the "Starter" and then backed up by the "Supporter."

*Interpreting the problem*
***Starter**: Now let us discuss our learners. Considering that the learners are seniors, we need to pay special attention to their learning abilities and their problems associated with aging. Go ahead and share your ideas.*
***Challenger**: I agree; but we also need to determine their common characteristics. At this point, designing personalized learning is difficult.*
*Identifying/sharing/comparing relevant information*
***Arguer**: Seniors may have reduced reaction capacities, so the instruction should be slowed down for them.*
***Supporter**: Their memory efficiency would also be reduced.*
***Arguer**: They may have other chronic disabilities, such as declined learning ability and less familiarity with electronic products.*
*Developing solutions*
***Timer**: Our common view is that the seniors have reduced memory efficiency. We must take this into consideration in the design.*
*Proposing alternative solutions*
***Starter**: We also need to think of ways by which we can provide instruction to a group with different starting points.*
*Negotiating to avoid inconsistency*
***Challenger**: However, it is not realistic to provide each of the learners with different instructions. We need to think of ways to narrow down their differences.*
***Arguer**: Yes, try to make use of their common ground.*
***Supporter**: Right.*
***Questioner**: Yeah, last time, we talked about giving an introduction first, then showing them a video for practice until they master it.*
*Making a claim*
***Starter**: All right, at this point, we must design a group instruction plan. We can then discuss ways to differentiate the instruction later.*

In this same unit of discourse, group cognition was constituted step by step as the discussion progressed. After the "Starter" introduced a new point, the "Arguer" and the "Starter" expressed their respective statements. Then, the "Timer" stated the common view of the group and referred to it as "a consideration for design." After the "Starter" added an alternative solution, the "Arguer" and "Supporter" agreed to "make use of their common ground" based on the statement provided by the "Challenger." The "Questioner" building on the message of the "Timer" interpreted the idea by quoting an external resource of a previous discussion. On the basis of *Negotiating inconsistency among the "Challenger", "Arguer", "Supporter" and "Questioner"*, the group finally reached an agreement as the "Starter" made the conclusion. Given

that the group cognitive process is a social meaning-making practice, in this case, individual minds with different roles co-constructed meaning by understanding one another.

## 5. Discussion and conclusion

Role assignment methods have been practiced as a kind of structuring design within the context of CSCL to promote effective collaboration. This is based on the assumption that the interdependencies and individual accountabilities of a group could be promoted with this intervention on the division of labor, thus leading to effective performance in collaborative knowledge construction. In this study, we designed a role structure to engage students in a computer-supported collaborative learning program, by intentionally modeling the group cognitive process. The findings showed better understanding among the students on how a role structure design could be used in modeling the group cognitive process. These findings can shed light on how the role structure can be better designed as an intervention to encourage students to actively participate the meaning-making process with fellow group members.

The findings suggest that the role structure design is helpful in promoting interdependencies and individual accountability. This finding is in line with those of previous studies, such as Seo (2007), Spada (2010), and others. The rather high performance of assigned roles also confirms the value of the structure design in promoting participation rates, which echoes the findings of Schellens et al. (2007), De Wever et al. (2010), and Strijbos and Weinberger (2010). Similarly, the value of alleviating the problem of non-participation, as presented by Strijbos and De Laat (2010), has also been affirmed. In addition, the findings of this study appear to confirm that the value of the combined design of roles facilitates the online collaboration process and keeps people focused on the issues under discussion, as demonstrated in previous role designs (De Wever et al., 2007; Pilkington & Kuminek, 2004; Strijbos et al., 2004, 2007). Furthermore, taking group cognition as the unit of analysis, the findings of the current study present evidence of interpreting the value of possible further endeavors in mapping roles within a cognitive process context through group discourse.

However, the findings also reveal that the roles have developed different levels of importance during the group discourse. The fact that the "Starter" role is best enacted and the "Supporter" has the lowest level of achievement has a significant impact on understanding the interplay between the function of the assumed role and the actual performance of the student who enacts that role. For example, the role of "Starter" has been developed into that of the group leader because it has been his/her duty to initiate a topic, develop a solution, and arrive at conclusions. In the case of the "Supporter," its low performance could be attributed to its easy-to-do features, because the other students can easily undertake the function of "Supporter" (e.g., "I agree with you"). Therefore, the real role of the "Supporter" may have been inactive compared with the other roles. Perhaps the role of "Supporter" should be assumed by all members. At the beginning, some students also reported a slight constraint because of the prompts, which affected their free discussion although they later became used to it.

We argue for another possibility that greater freedom related to role taking would result in further group meaning-making when students are fully engaged in group discussions. This is in accordance with the findings of De Wever et al. (2008, 2010), that is, the most effective time of role assignment is during the start of the discussions. We note that one limitation of using content analysis is that most off-topic social postings have been excluded from the analysis. Postings such as technology-related ones that may have an impact on the group discussion have been excluded from the analysis. Future research may, therefore, include these postings in the analysis where sub-themes and themes could be generated.

As an attempt to integrate functional and cognitive engagement into roles, which aim to map the roles with the cognitive process by looking at a group discourse, some values of significance and possible future endeavors should be considered. Taking the group cognition as an analysis unit and the performance of roles in the cognitive process, the designed roles can be mapped into the related cognitive components [developed by referring to Stahl (2007)] and the problem-solving constructs. The mapping of the roles and the group cognitive components are significant in modeling the group problem-solving process. However, further investigation on the factors that influence COA and PD scores would be the next step of our research. Designing a role structure has been verified as an effective method to enhance collaboration, and our new research shall focus more on the true meaning-making process that occurs under this structure. We cannot deny that this theme of role structure may have negative effects on activating discussions, but for students who are not fully engaged in the discussion, this method is still a good way to foster their engagement.

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# An evaluation of online learning to teach practical competencies in undergraduate health science students

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ABSTRACT

The aim of this study was to evaluate the use of online delivery as a pedagogical approach to teach the practical and theoretical skills required for resting ECG electrode placement and interpretation.
*Results:* Comparable results were found for all variables between the two groups, apart from electrode placement, whereby students in the classroom based group were significantly more accurate than their counterparts in the online group ($p < 0.05$). The effect size of this difference was large (0.91), whereas the effect size for all other measured variables were classified as small (0–0.49).
*Conclusion:* Online learning is an effective study mode in both theoretical and practical application; however consideration must be taken of the types of practical skills which it is used for. More complex practical skills requiring haptic awareness may best be delivered within a classroom setting if feasible, whereby the instructor can provide immediate feedback.

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## 1. Introduction

There is an ongoing drive within higher education institutions (HEI) to continually develop and enhance their pedagogical approach, whilst recruiting optimum student numbers. Online learning represents a study mode that may enhance both these factors and which is ever-increasing in popularity, largely due to advances in technological delivery modalities (Smith, Gillham, McCuthcheon, & Ziaian, 2011). Online learning represents a medium through which universities may deliver courses to students outside of its geographical catchment area, and increase the efficiency of on-campus delivery. There are a number of strengths and limitations associated with this pedagogical approach, which must be considered within the context of specific course objectives, before a decision as to appropriateness may be made. A key strength of online learning is the degree of flexibility that it allows, which may not be available in a more traditional classroom based course. For example, this educational mode provides the opportunity for asynchronous or threaded discussion, without the logistical difficulties of arranging times and locations for students to meet (Hillman & Corkery, 2010), thus increasing accessibility of university education to a wider student demographic (Paulius et al., 2010). In addition, online learning allows development of technological skills, which are of particular relevance in modern society (Bonk, 2009) and also employs many of the key tenets of student centred learning (Pederson & Liu, 2003), enhancing the development of higher order cognitive skills, including application, synthesis and evaluation (Lee, Mann, & Frank, 2010; Tsou et al., 2009).

There are however, pedagogical limitations associated with the use of online learning. Often cited within the literature as a negative aspect of online learning are issues related to engagement (McQuiggan, 2007), social isolation, lack of confidence in peer advice and knowledge, and technological difficulties (Petrides, 2002; Song, Singleton, Hill, & Dwa Koh, 2004; Vonderwell, 2003). It has also been suggested that a proportion of potential employers may not perceive online learning as an entirely credible process (Huss, 2007). While each of these factors must be considered, it is important to note that many of these limitations may be overcome with appropriate instructional design (Song et al., 2004), institutional support (Leist & Travis, 2010) and educator presence (O'Neill & McMahon, 2005).

At present there is a paucity of empirical evidence available that evaluates objective outcomes related to online learning as opposed to more traditional, classroom based learning techniques, particularly regarding the use of this study modality to teach practical skills. Practical application of skills with clients and patients is essential to the development and successful performance of health professionals. The limited evidence available does appear to suggest that online or distance modalities may be comparable to more traditional pedagogical approaches in relation to achievement of learning outcomes. For example, Cason and Stiller (2010) explored the efficacy of online versus classroom based first aid training for laypeople, and showed comparable learning outcomes for both groups when assessed by instructor. This study reported low achievement rates in both groups however, as ascertained through objective assessment criteria taken directly from the mannequin (Cason & Stiller, 2010). This raises questions as to the appropriateness of the

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course delivered relative to the desired learning outcomes, so impacting on the reliability of the information obtained. In addition, participants in this study were not randomised into the two groups, and self-selection as a result of an inherent preference for one study mode over another may potentially have biased the results. Maloney, Storr, Paynter, Morgan, and Ilic (2013) investigated the use of three different educational methods as an adjunct to traditional instructor-led sessions to teach practical skills in a group of third year physiotherapy students. These educational methods included traditional tutorial based teaching; pre-recorded video tutorials, integrated within the traditional setting and reflective self-video of clinical skills. All students performed comparably in the objective structured clinical examination (OSCE), although students allocated to the two alternative teaching groups reported a higher perceived educational value. This finding is in agreement with other literature that suggests comparable outcomes between video and "live" demonstrations (Chung, Siu, Po, Lam, & Wong, 2010). Collectively, the results from these studies appear to support the use of alternative educational methods to teach practical skills; however, the authors stressed the importance of considering the attributes of the clinical skill in question, along with other issues including IT support, and infrastructure. In addition, Maloney et al. (2013) evaluated a blended resource approach integrating the video resources seamlessly within the class. Limited research is available however, investigating the use of a teaching package delivered wholly online, without the presence of the educator. Further research of this kind is required, to assess the efficacy of online learning to teach practical skills as well as theoretical content.

Overall, the available evidence appears to indicate that online learning for practical skills may be an effective means of delivery for higher education institutions, although this assertion is not well grounded in empirical data, due to the aforementioned paucity of evidence. In addition, the constant development of technological aids and web influences create an ongoing evolution of the way in which online courses are designed and delivered (Song et al., 2004). Continued evaluation and research is necessary to ensure that an optimum learning experience is provided to the student. The aim of this study therefore was to evaluate the use of a wholly online learning package, as a pedagogical approach to teach the practical and theoretical skills required for resting electrocardiography (ECG) electrode placement and waveform interpretation in a group of first year undergraduate health science students.

## 2. Methods

First year undergraduate students from a School of Health Sciences were invited via email to take part in a session examining ECG theory, preparation and electrode placement, and randomly allocated to one of two groups. One group undertook a traditional classroom based model, as typically used within the school, while the other group took part in a session that was comprised entirely of online materials. Theoretical and practical competencies were assessed one week after the teaching session.

### *2.1. Population and recruitment*

A recruitment email was circulated to all first year undergraduate students (n = 147) within a School of Health Sciences. Students were enrolled on one of four courses (diagnostic radiography, physiotherapy, occupational therapy or applied sport and exercise science). Any student that had prior knowledge or experience of ECG theory or electrode placement was excluded from the study to control for the confounding influence of prior knowledge. All students within these cohorts had previously completed a Scottish Credit and Qualifications Framework (SCQF) level 7 30 credit module in human anatomy and physiology and had a basic understanding of cardiac anatomy and physiology prior to participating in this research project. The aforementioned module was delivered as an online blended student centred course and assessed via multiple choice question (MCQ) examination. All students were therefore familiarised with this mode of delivery and assessment, reducing the possibility of biased results through greater familiarity with one mode of teaching over another. Participant confidentiality and anonymity was assured and all participants were reminded of their right to withdraw from the study at any time.

### *2.2. Teaching sessions*

Students who volunteered for this project were randomly allocated to one of two courses (a classroom based or online course). Both of these courses taught the theory and practical application of ECG electrode placement and interpretation. The same teaching resources were used for both the classroom based and online sessions as outlined below. Classroom based students were provided with the teaching materials after the session was completed. The online course was uploaded to a purpose designed Modular Object-Oriented Dynamic Learning Environment (Moodle) page on the same day that the classroom based session was delivered and remained open for the next week. All students then returned for testing the following week, whereby they took part in both a practical and theoretical examination of knowledge. The Moodle page was password protected and accessible to participants in the online group only. Clear instructions were provided to all participants on the purpose of the study and the importance of not sharing materials with their counterparts in the other group.

### *2.3. Teacher led session*

This session commenced with a short didactic lecture that revised basic cardiac anatomy and physiology. Theoretical information was then provided on the practical knowledge necessary to prepare the subject, place the ECG electrodes and interpret the resultant recording, in accordance with the waveforms and the corresponding phase of the heartbeat. The students were then provided with a brief break, which was followed by a tutorial, whereby the practical skills of ECG preparation and placement were taught, using the 4 stage approach to student learning, as proposed by Peyton (1998). These four stages included a demonstration phase, deconstruction phase, comprehension phase and performance phase (Greif, Egger, Basciani, Lockey, & Vogt, 2010). The didactic content was split up into smaller components (≈20 mins) to maintain engagement and improve concentration (Stuart & Rutherford, 1978). A volunteer patient attended the practical session for demonstrations 1–3, and the students then took turns to connect this volunteer to the ECG monitor (Cortex Metalyser 3B, Cranlea, UK). While waiting for their turn to practice on the volunteer, students practiced electrode placement on resuscitation dolls that were made available during the session.

### *2.4. Online course*

The same teaching materials were used for development of the online course. Audio visual materials were developed from the same PowerPoint™ presentation using Articulate™ software. This software allows the creator to record narration throughout a PowerPoint™ presentation. This presentation was then uploaded to a Moodle page that was created specifically for this project. In addition, four video clips detailing the 4 stage approach to practical demonstration were recorded using the Scotia Medical Observation and Training System (SMOTS™) (Scotia UK, Ltd) and the resultant video clips were uploaded to the Moodle page. These video clips followed the exact same 4 stage approach as used within the classroom based session, however the 3rd clip included pauses for students to provide instructions, while the 4th clip instructed the students to find a willing volunteer on whom to practice identifying landmark sites. Discussion forums were populated for students to ask any questions on the topics. Educator consistency was ensured, and the same researcher who performed the live demonstrations recorded the video clips, as with the presentation articulation and delivery.

### 2.5. Outcome measures

Theoretical and practical learnt knowledge was assessed using a MCQ and a practical examination respectively. These tools have previously been identified as valid and reliable assessment tools, provided they are developed in accordance with recommended guidelines and constructively aligned to the pre-determined learning outcomes (Brady, 2005; Considine, Botte, & Thomas, 2005; Graham, Zubiaurre Bitzer, & Anderson, 2013; Smith, Muldoon, & Biesty, 2012). Both tools assess distinct components of learning, providing a more comprehensive assessment of learning outcomes than either tool alone. Twenty minutes were allowed for completion of the MCQ and it contained questions related to basic cardiac anatomy and physiology and the principles of resting ECG placement and interpretation. Content validity was ascertained through seeking the advice of colleagues experienced in teaching and assessment at this level. In addition, the questionnaire was piloted on a student at a similar level to those who took part in the study to ensure that the questions were clear and coherent. The objective structured practical exam (OSPE) lasted approximately 15 minutes and involved completion of the full procedure for ECG preparation and placement by the student under assessment. Volunteer patients were recruited for this examination, and the students were objectively scored by the researcher under the following headings: introduction and ID check, explanation of procedures, chest preparation, electrode placement, connection to monitor; identification of waveforms and explanation, mannerism and professionalism, using a rating system in a series of stations. Prior to the OSPE the assessor conducted a practice session with a volunteer to trial the scoring, technical and observational requirements of the OSPE. These particular assessment tools were selected as they are commonly used assessment tools within the health sciences, so enhancing the ecological validity of the results attained.

### 2.6. Data analysis

All data were analysed using SPSS version 17.0 Normality of data distribution was testing using the Shapiro Wilks test. Parametric or non-parametric tests of difference were chosen based on the results of this test, i.e. an independent samples t-test or a Mann Whitney U test. Significance was accepted at the level of $p < 0.05$ for all statistical tests. The effect sizes of differences between the groups were calculated using the Cohen's D method and the pooled standard deviation. An observed power analysis was conducted using the mean of both groups and a pooled standard deviation. Probability of rejecting the null hypothesis if it was false was accepted at a level of 0.80.

## 3. Results

Twenty-nine participants initially volunteered to take part in this study, and were randomly allocated to either the classroom or online group, with 22 of these completing the final assessment representing an attrition rate of 24% (4 and 3 participants withdrew from the classroom and online groups, respectively). Of those that completed the final assessment, 10 were in the classroom based group and 12 completed the online course. Examination of the Moodle user statistics revealed that all participants within the online group logged into the page and accessed the resources, which included the course overview; video clips; resources (e.g. PowerPoint and Articulate presentations) and all students also attempted to complete the mini practice quiz provided within each section. No students within the online group engaged with the online discussion forum. Participants showed a mean ± SD of 45 ± 18 total actions on the Moodle site (range 24–91). Results of the observed power analysis resulted in a value of 0.99 for the electrode placement element of the OSPE, while no other variable reached the recommended threshold of 0.80 (see Table 1).

**Table 1**
Breakdown of OSPE scores.

| Component | Classroom | Online | Effect size | Power |
|---|---|---|---|---|
| *Introduction* | 4.5 ± 1 | 4 ± 1.0 | 0.36 | 0.4 |
| *Explanation of procedures* | 4 ± 1.2 | 4 ± 0.6 | 0.00 | 0.02 |
| *Client preparation* | 6.5 ± 1.2 | 7.4 ± 1.6 | -0.49 | 0.63 |
| *Electrode placement* | 17.6 ± 1.8 | 15.5 ± 2.3 * | 0.91 | 0.99 |
| *Connection to monitor* | 9 ± 3.2 | 8.9 ± 1.6 | 0.04 | 0.04 |
| *Waveform explanation* | 4.6 ± 1.2 | 4.9 ± 1.6 | -0.20 | 0.15 |
| *Professionalism* | 3.3 ± 0.8 | 3.3 ± 0.7 | -0.05 | 0.04 |

* Denotes a significant difference between the groups, i.e. $p < 0.05$, effect size represented by Cohen's D statistic. All scores are presented as mean ± standard deviation.

### 3.1. Multiple choice questionnaire

The classroom and online groups scored a mean ± SD of 17.8 ± 1.6 and 17.3 ± 2.3 marks respectively in the MCQ, out of a possible 20. An independent sample t-test, which was selected based on the parametric distribution of the data revealed no significant differences between the groups ($p > 0.05$) and an effect size of 0.25.

### 3.2. Objective structured practical exam (OSPE)

All OSPE components showed a non-parametric distribution and were assessed through the Mann-Whitney U test, apart from the data related to electrode placement, which had a parametric distribution and was assessed by an independent sample t-test. The classroom and online groups scored a mean ± SD of 49.5 ± 5.2 and 48 ± 5.2 marks respectively in the OSPE, out of a possible 60 marks. No significant differences for total OSPE scores were observed between the groups ($p > 0.05$) and effect size was calculated as -0.24.

The breakdown of OSPE marks, according to all assessed components are presented in Table 1. The classroom based group were shown to perform significantly better in the electrode placement component, than their counterparts in the online group ($p = 0.03$). Effect size is also presented in Table 1. For electrode placement it was calculated as 0.91, representing a large practical effect size according to the criteria proposed by Jacob Cohen (1988), as identified by Vincent & Weir (2012). No significant differences were identified for any other OSPE component and effect size for variables apart from electrode placement were classified as small (Range: 0–0.49; see Table 1).

## 4. Discussion

The aim of this study was to compare the use of an online and a classroom based learning package, designed to teach the theoretical and practical skills and knowledge required for basic ECG placement and interpretation to a group of first year undergraduate health science students. Practical competency is traditionally taught through classroom based, teacher-led methods. With the constant evolution of higher education strategies and approaches, ongoing research is required in order to evaluate the most effective pedagogical approaches for essential professional competencies including practical skills. Results from this study appear to indicate that the online course provided comparable learning outcomes for all theoretical and most practical elements of this skill. The online group was however significantly less accurate at placing the ECG electrodes than the classroom based group and calculation of effect size according to the Cohens D method indicated a large effect. This appears to indicate that the online course was a less effective teaching modality than the more traditional, classroom based approach for this particular element of the practical skill.

In order to develop an online course that was embedded in pedagogical theory, and constructively aligned to the pre-determined learning outcomes, an in-depth review of the literature was undertaken, followed by a thorough inventory of online modalities available within the

HEI. It appears that instructional design and clear and specific direction are key attributes of a successful online course (Song et al., 2004). In accordance with this, learning outcomes were clearly articulated at the beginning of the module. The use of the Articulate™ software was beneficial, as the recorded dialogue enabled remote explanation and clarification be made to students within the online group.

The results attained within the current study do point to the effectiveness of online learning for many of the course learning outcomes. Specifically, students attained comparable results on the MCQ, pointing to the effectiveness of this approach as a means of theoretical knowledge delivery. As outlined above, the online course was designed in accordance with current research findings and recommendations for best practice, which may in part explain the positive results noted with this approach. The overall OSPE results were also comparable between the groups, indicating that most aspects of practical skill delivery were similarly conveyed using the online Moodle e-resources. In contrast with the literature however (Cason & Stiller, 2010), students in the classroom based group were significantly more accurate at placing the ECG electrodes than their counterparts in the online group and this was calculated as having a large effect (0.91). Much of the literature suggests consideration of the attributes of the skill in question, prior to making a decision on the suitability of online delivery for that particular skill (Maloney et al., 2013). Electrode placement is quite a complex skill, particularly as the bony landmarks required for placement cannot always be seen, and must be located through palpation. Palpating the human body is inherently unique between individuals, and requires haptic awareness of the area, in addition to visual location of landmarks. A live volunteer was brought in for electrode placement demonstration in both the classroom and online session. Every effort was made to clearly articulate the location of the landmarks in both sessions, however only two senses were available to the online participants (i.e. sight and sound), whereas the classroom based group could additionally employ tactile/kinaesthetic approaches to locate bony landmarks, while the instructor was ever present to provide live-time feedback. The online participants were encouraged to locate these landmarks on themselves and a willing volunteer, however the opportunity to actually palpate for the landmarks and to get live-time feedback was not available to this group, and this may explain the significant differences in electrode placement scores reported within this study. It must be noted that this difference did not impact on the overall grade profile, however it may be taken to indicate that not all practical skills are suitable for online delivery, and those skills or elements of a skill that require a greater degree of haptic awareness and optimal precision may best be suited to face to face teaching modalities.

Although there are many practical and theoretical applications of this project, a number of limitations are present which may impact on interpretation of results, and should be considered. Sample size was small, and although the observed power analysis appeared to indicate that the sample size was sufficient to reject the null hypothesis if it was false for the electrode placement component of the OSPE (0.99), no other component reached the accepted probability of 0.80 (range 0.04–0.63). The low probability calculated for other variables may be taken to indicate that the study did not have sufficient power to identify changes here, or more likely, that no significant changes were present to identify. Results from this observed power analysis when considered in context of the calculated effect sizes appear to reduce the likelihood that a type 1 error occurred in relation to electrode placement, although the possibility of a type 2 error occurring for other variables cannot be excluded. Students volunteered for this project, and it is possible that a participant bias may exist, as those who volunteered may be the more diligent and motivated of the cohort. In addition, although the aim of this study was to provide empirical evidence as to the use of online and classroom based pedagogical approaches, it is important to note that learning is a complex phenomenon (Pritchard, 2009) which cannot necessarily be captured in its entirety through assessments such as MCQ's and OSPE's. In particular, many of the attributes of student led learning, of which online delivery is an example of, include elements such as problem solving, critical thinking, professionalism, and improved skill retention (Robert, Lorenzo, Cynthia, & Abbott, 2004). Many of these attributes cannot necessarily be captured with an objective summative assessment. In addition the assessment tools were purposely created for this study to ensure they were constructively aligned to the specific learning outcomes of the course, and while every effort was made to adhere to recommended guidelines and to ensure that they were fit for purpose these particular tools have not been specifically validated, and so statistics related to their validity and reliability are not available. In order to more conclusively address these issues, future longitudinal and mixed method studies is required.

## 5. Practical implications for teaching practice

Online learning may provide an efficient and effective means of theoretical content delivery, particularly within modules whereby direct contact time may be limited. This blended approach (Davies, Ramsay, Lindfield, & Couperwaithe, 2005) may allow a more effective use of classroom time, as it does appear that some practical skills may be best taught in person and so classroom time could be used for live demonstrations, and to allow the student time to practice their skills while the facilitator is present. Increasing the use of online delivery for suitable elements of the course also means that classroom time can be spent on discussing more complex aspects of the course, allowing learner's time to ask questions and gain feedback on their progression.

The integration of online modalities may provide an enhancement to classroom based sessions. For example, recording classroom based sessions, and then providing these clips to the students via Moodle, will enable the student to replay, pause and rewind the session as often as they like, so allowing continued practice, potentially improving skill acquisition. This will enable the students to clarify and consolidate information in their own time. In addition, the playing of recorded clips on a loop during practical sessions may allow students to continuously check requirements, allowing the facilitator to spend their time providing constructive feedback to the students, rather than continuously repeating demonstrations. While the results of the current study do appear to indicate that the online course created was less effective at teaching more complex practical skills, this may potentially be overcome through evolving the package created to more specifically tackle these issues. For example, integration of an online tactile tool e.g. Virtual ECG (Richards, 2012) whereby the students could simulate electrode placement on a virtual chest and receive immediate computer mediated feedback. In addition, use of a virtual cadaver, allowing the student to view bony anatomical landmarks both with and without skin may enhance the ability of the student to visualise the exact location of skeletal landmarks and subcutaneous sites.

## 6. Summary and conclusion

The aim of this study was to evaluate the use of online delivery as a pedagogical approach to teach the practical and theoretical skills required for resting ECG placement and interpretation. Results appear to indicate that many of the learning outcomes were comparably achieved using both study modes, however the students within the classroom based group were significantly more accurate at placing the ECG electrodes than were their counterparts in the online group. Based on these findings, it is thought that online learning has a key role to play within teaching delivery, however when possible, the teaching of more complex skills, particularly those that require optimum precision and a greater degree of haptic awareness, may be better suited to classroom based sessions.

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# Examining the necessary condition for engagement in an online learning environment based on learning analytics approach: The role of the instructor

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ABSTRACT

This study analyzes the impact of an instructor on the students' engagement using learning analytics approach by tracking one university's log data of teaching and learning activities in a web-based learning platform. Based on the tracking data and theoretical analysis, this study builds a teaching and learning interaction activity model to show how the instructor's course preparation and assistance activities affect different dimensions of student engagement activities and the relationship between these activities. The results reveal that an instructor's course preparation is significantly positively related to the students' viewing activities, while instructor's guidance and assistance has a significant impact on the students' completing learning tasks. The study also indicates that the students' viewing activities have a direct positive influence on their completing learning tasks activities. Students' completing learning tasks exert direct positive influence on their interaction for learning, while their viewing activities have an indirect impact on their interaction activities.

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## 1. Introduction

### 1.1. Research background

Information technology applied in higher education has gradually influenced teaching and learning strategies, methods, activities, as well as the way students are engaging with their study (Beer, Clark, & Jones, 2010; Coates, 2007; Lane, 2009). The degree to which students have been actively engaged in their academic work deeply affects the level of their learning outcomes, cognitive development and educational quality (Hu & Kuh, 2002; Kuh, 2003; Smith, Sheppard, Johnson, & Johnson, 2005). How students engage with the online courses and how the role of the instructor impacts students' engagement are issues that are attracting increasing attention in the online learning environment. Discussing these engagement issues can help examine the students' online learning activities, and evaluate the quality of online teaching and learning, so as to help the instructors design appropriate online courses, as well as implement necessary support strategies to improve the quality of online learning (Richardson & Newby, 2006; Robinson & Hullinger, 2008).

Currently, more and more studies of online education have begun to focus on student engagement. Previous works refer to various aspects of engagement, such as the relationship of self regulation and student engagement (Sun & Rueda, 2012), the impact of technology on student engagement (Chen, Lambert, & Guidry, 2010; Nelson Laird & Kuh, 2005), student cognitive engagement (Richardson & Newby, 2006), and student engagement characteristics (Coates, 2007). Most of the above studies have revealed that the instructors seemed to have great effect on students learning experience, and it is the instructor's responsibility to sustain and facilitate student engagement in online education (Robinson & Hullinger, 2008; Smith, Sheppard, Johnson & Johnson, 2005). Although those studies have indicated the importance of the instructor in the online learning environment, most of them focused on the students' aspects to examine the student engagement topic. Yet, very little research has directly looked at the impact of the instructor on student engagement. Furthermore, some studies have focused on the instructor' role on student engagement, but most of them are primarily based on a questionnaire or a survey (Bangert, 2008; Garrison & Cleveland-Innes, 2005; Shea, Li, & Pickett, 2006). There are few studies using big data collection to analyze student engagement in the online environment (Beer, Clark & Jones, 2010; Morris, Finnegan, & Wu, 2005; Phillips et al., 2010). Some researchers have used tracking data of student activities in the learning management system (LMS) to investigate student's learning, they primarily emphasized the "student" as the analysis unit, ignoring the instructor's role and the relationship between students and instructors. Therefore, this study will try to focus on three aspects to investigate student engagement: 1) examining the instructor's role on student engagement; 2) using learning analytics approach to investigate student engagement; and 3) employing "course" as the analysis unit to add the instructors' activities tracking data to examine

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the impact of the instructors on students and the relationship between the instructors and students.

Recently, the learning analytics field based on big data analysis has captured more and more attention of researchers. In the first International Conference on Learning Analytics and Knowledge, learning analytics is defined as "the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs" (Long & Siemens, 2011). In the information technology environment, a large amount of data about online teaching and learning activities is available, yet effective use of these data to improve teaching and learning has not been optimized. Large data sets exist in a university and online learning environments. However, on the one hand, these data are not easy to acquire; on the other hand, in higher education, the utilization of these data is limited and inefficient (Beer, Clark & Jones, 2010; Dawson, Heathcote, & Poole, 2010), and there are some delays in analyzing those data and providing immediate feedback (Long & Siemens, 2011). Most organizations still focus on the data level, and have not changed the data to meaningful information through analysis process (Elias, 2011).

### *1.2. The main purpose of the study*

Compared with studies using questionnaire or survey approaches to investigate student engagement in the online environment, learning analytics can capture direct data of online activities, providing more authentic, objective, and timely evidence (Lockyer, Heathcote, & Dawson, 2013; Phillips et al., 2010). This study focuses on the tracking data in an online learning environment on a college level. It aims to examine how the role of instructor affects students' engagement in the online learning environment, in order to provide suggestions for the more effective use of information technology development in higher education.

## 2. Related work

### *2.1. Engagement in the online learning environment*

Student engagement typically refers to time and effort students devote to their academic experiences (Jennings & Angelo, 2006; Kuh, 2003). When investigating student engagement in the online learning environment, it is necessary to determine the indicators or measurement of engagement. The earlier, influential and best known research about engagement measurements is the "Seven Principles for Good Practice in Undergraduate Education" (Chickering & Gamson, 1987). Based on the principles, the National Survey of Student Engagement (NSSE, 2003) was designed to assess the dimensions of college-level student engagement.

Coates (2007) used iterative analytical process to develop four clusters about engagement patterns in online and general learning practices based on the data obtained by the Student Engagement Questionnaire (SEQ) (Coates, 2006) in several Australian universities. Among the SEQ, seven scales are designed to measure online engagement of campus-based students, such as concerning the students' use of online learning systems to do academic work with their peers, and interaction with others in online discussion.

Currently, there is a significant body of research focusing on the factors that influence student engagement in college-level online learning environment. For example, Chen, Lambert and Guidry (2010) found that there exists a positive relationship between the internet and web-based learning technologies and student engagement and learning outcomes through multiple regression analysis of survey data gathered from the 2008 administration of NSSE. Sun and Rueda (2012) demonstrated that situational interest and self-regulation are significantly related with the behavioral, emotional and cognitive engagement. Similarly, Richardson and Newby (2006) specifically examined the impact of students' prior on-line experience, students' different program area focus, gender, age and employment status on the cognitive engagement such as students' motivations and strategies in online learning courses.

### *2.2. Instructor's role in the online learning environment*

In a web-based learning environment, the instructor's role needs to be reconsidered. Instead of just imparting knowledge, the instructors need to provide more guidance and assistance to learners, consider how to integrate online resources to organize learning content, create a high quality online learning environment, and emphasize course process management to stimulate students' learning motivation and enhance learning effect (Coppola, Hiltz, & Rotter, 2001; Marks, Sibley, & Arbaugh, 2005). The concept of teaching presence is regarded as the key concept for examining the instructor's role in much online learning researches. Teaching presence is one of the important elements in the Community of Inquiry (CoI) framework proposed by Garrison, Anderson, and Archer (2000). They demonstrated that cognitive, social and teaching presence are three elements integrated in an online community for sustainability of a community of inquiry in higher education. They regarded the design of the educational experience and facilitation as the two general functions of teaching presence. Shea, Li and Pickett (2006) clustered teaching presence items into two categories described as Instructional Design and Organization and Directed Facilitation, which focus on preparation before the class and assistance during and after the class.

Further researches have investigated the impact of teaching presence on student learning in the online learning environment based on the concepts of CoI framework. For example, Garrison and Cleveland-Innes (2005) indicated that teaching presence, such as design and teaching approach, is crucial for the adoption of a deep approach to student learning. A study by Shea, Li and Pickett (2006) also identified that active teaching presence has a positive impact on students' sense of learning community through a survey-based study conducted in a large asynchronous learning environment in which 1067 students from 32 colleges participated. When the instructors provide effective instructional design and organization, and active guidance, students displayed higher levels of learning community. Moreover, Bangert (2008) examined the influence of social and teaching presence on the level of online learners' critical inquiry, and found that the social presence combined with teaching presence can facilitate deep levels of critical inquiry. Most of those researches emphasize the impact of one or some dimensions of teaching presence or social presence on students learning, few of them have considered the whole picture of the relationship among teaching, social and cognitive presence (Garrison, Cleveland-Innes, & Fung, 2010). This study will attempt to address the issue by exploring whole picture of the impact of the instructor on student engagement.

More importantly, the above studies examine student engagement and the role of instructor through the insight from students' experience and their feedback by using a survey or questionnaire method, therefore they lack more objective evidence which can demonstrate more accurate information about interactions among instructor and students (Carini, Kuh, & Klein, 2006; Lockyer, Heathcote & Dawson, 2013; Phillips et al., 2010).

### *2.3. Learning analytics used in the studies on student engagement*

Long and Siemens (2011) proposed that the most critical factor influencing future higher education is big data and its related analysis. Big data analysis can help the higher education institution managers and educators to improve decision-making process, optimize the allocation of resources, monitor students' difficulties in time and offer support, as well as change higher education academic mode and teaching pedagogies and methods. In other words, the purpose of the learning analytics based on large data is not just evaluation. The more important objective is to adjust the content, strategies and activities of the learning

process, and provide feedback and intervention immediately in order to promote the quality of teaching and learning.

With regard to the studies about using learning analytics to examine student engagement in an online learning environment, Phillips et al. (2010) investigated how students engage with a lecture-recording supported learning system in three different units of two universities. By utilizing usage logs of the system, ten different usage behaviors are developed according to students' hit frequencies in the lecture-capture system. Besides analyzing usage logs of learners' activities in online environments, based on eight of the above conceptual usage behavior patterns, they continued to have semi-structured interview with six students to supplement their initial stages of research. In their study, the interviewee students' course final grades are included in the research, and the relationship between students' learning behavior patterns and the learning outcomes is created.

According to student access tracking logs of three undergraduate courses, Morris, Finnegan and Wu (2005) examined student engagement behavior and its relationship with students' persistence and achievement in online courses. By analyzing the frequency and duration of participation, such as number of content pages viewed and discussion posts read, and seconds spent viewing content pages and reading discussions, etc., the researchers indicated that active engagement is a significant factor in successful online learning. Besides comparing LMS usage information and grade performance, Beer, Clark and Jones (2010) also considered instructors' participation in the discussion forums, and found that if the instructors participate more in the discussion forums, students had higher engagement. The research considered the impact of the instructor on student engagement. However, it only mentioned students' different level of engagement depending on whether the instructors participate in discussion forums or not. Instructor's specific activities in the forums were not examined.

Other recent research has specifically considered students social networks by obtaining data from the instructors and students' activities in online discussion forums (Cambridge & Perez-Lopez, 2012; Dawson, Bakharia, & Heathcote, 2010; Rahman & Dron, 2012; Wise, Zhao, & Hausknecht, 2013).

Most of the related studies have considered some dimensions of student activities, such as viewing content pages and participating discussion board, especially students–instructor interaction activities in the discussion forum. Further investigations are needed into more aspects of student activities and instructor impact in the online learning environment. Our study will examine more overall and specific dimensions and aspects of the instructor's and students' activities, and investigate more details about the relationship among those activities.

As for the analysis unit of researches using tracking data to examine teaching and learning, most of previous studies have employed "student" as the unit in one course to analyze the correlation between student activities and their academic achievement. For example, Macfadyen and Dawson (2010) employed 118 students as the sample, capturing their LMS tracking data in one online undergraduate course to study which variables could accurately predict student achievement. In research conducted by Smith, Lange, and Huston (2012), 539 students were chosen as the sample in one online freshman-level course. The researchers tried to identify if the key variables of students' activities could be effectively used to predict students' course outcome. Some studies have expanded their research focus to more courses, but still used the student as the analysis unit. Morris, Finnegan and Wu (2005) used 354 students enrolled in three courses to assess the relationship between student online participation behavior and their achievement. Falakmasir and Habibi (2010) ranked online learning activities of 824 students in 11 courses based on their impact on students' final grades. While the research discussed above uses "student" as the analysis unit, instructor's activity tracking data records cannot be employed as the variables to examine the relationship between the instructors and students. Dawson, McWilliam, and Tan (2008) considered instructors' engagement in the context of whole institution level and faculty management level. In the whole institution level, instructors' number of interaction recorded by the LMS per full-time equivalent student in different department or teaching unit was compared. The whole institution level analysis can demonstrate the trends of instructor behavior and LMS adoption across the university. Analysis at the faculty level provided the senior management differences usage trends of instructors' interaction with students across schools in one teaching unit. The research has considered the impact of the instructor's role on student, however, it has not examined the specific instructor activities, and which activities influence students at what level or degree.

In order to address those above issues, this study will try to employ "course" as the analysis unit to use both students and instructors' behavioral attributes recorded in the LMS as variables to analyze more specifically and deeply about the impact of instructor on student engagement in the online learning environment.

## 3. Research context and methods

### 3.1. Research context

This study selected a university in south-east China which has implemented a LMS called Tsinghua Educational Online (THEOL), which has been used in nearly four hundred universities and colleges in China. The most important reason for choosing this university is its higher usage of the THEOL. The university has more than thirty thousand undergraduate students and more than four thousand faculty. The courses created in the platform have risen constantly since 2009.

THEOL provides comprehensive functions and tools to support students learning and the instructors teaching, mainly including modules related to course content learning; course administration tools providing course information such as course introduction, syllabus, course notification; interaction tools that permit students asking questions and communicating with their instructors and peers; assessment tools that assist the instructors to get feedback about students' learning process and effect as well as help students have self-evaluation. The description of THEOL tools is shown in Table 1.

### 3.2. Data collection

This study selected all the courses from September, 2012 to May, 2013 on THEOL in the university, as samples. The data was obtained from the platform's web log. The courses cover almost all the disciplines ranging from Science, Engineering, and Economics to History, Language, Education, Arts, etc. Courses which have not been registered by students and have zero visit record were deleted from the samples. The final total samples for this study are 900 courses.

This study used the number of related operations of the instructors and students in all sample courses on the online system, as the measurement indicators of online teaching and learning activities. Those data has been transformed to standardize data to make further analysis. Regarding the measurement, the majority of previous researches have focused on frequency variables of students, such as number of content pages, courseware or other related material and resource viewed (Falakmasir & Habibi, 2010; Morris, Finnegan & Wu, 2005), number of discussion

**Table 1**
Description of THEOL tools.

| Supporting tools | Description |
|---|---|
| Administration tools | Course introduction, instructor introduction, syllabus, course notification |
| Course content | Lesson plan, multimedia courseware, electronic books |
| Interaction tools | Discussion forum, frequently asked question (FAQ) area, email |
| Assessment tools | Course assignment, test, questionnaire |

messages read, posted and responded (Falakmasir & Habibi, 2010; Macfadyen & Dawson, 2010), number of email messages sent, number of assessments completed (Macfadyen & Dawson, 2010), number of times students log into a course (Campbell, Finnegan, & Collins, 2006; Smith, Lange & Huston, 2012), and number of assignments uploaded (Falakmasir & Habibi, 2010). Besides those measures, this study employs other variables of students and some frequency variables of instructor. In sum, this study used 16 variables, including:

1) the number of instructors entering the course,
2) the number of instructors posting course notification,
3) the number of instructors uploading learning materials,
4) the number of instructors identifying and presenting FAQs of the course,
5) the number of instructors administering course questionnaires,
6) the number of instructors administering assignments;
7) the number of students entering the course,
8) the number of students viewing course notification,
9) the number of students viewing learning materials,
10) the number of students completing course questionnaires,
11) the number of students making reflection notes,
12) the number of students completing and uploading assignments,
13) the number of students posting topics,
14) the number of students responding to discussion posts,
15) the number of students replied by the instructors and other students in the discussion forum; and
16) the number of students asking questions.

Within those variables, identifying and presenting FAQs refers to the instructor discovering students' frequently asked question during learning the course or summarizing typical questions students usually post in the discussion forum, addressing those problems and questions, and presenting them to students. Administering questionnaire refers to the instructor posting course questionnaire in order to understand students' learning attitude or opinions, gain feedback of students' learning process in time, in order to adjust teaching pace and methods. Students making reflection notes refer to students' records of the key points of the course content and their reflection at anytime in the learning process.

### 3.3. Data analysis

Guided by engagement activities, teaching presence and online interaction researches and theories, this study acquires five latent factors through those 16 variables, including preparation activities by instructor, guidance and assistance activities by instructor, viewing activities by students, completing learning task activities by students, and interaction for learning. A Structural Equation Modeling (SEM) has been established to analyze group interactive activities among college instructors and students in an online learning environment to explore instructor's impact on student engagement.

By using the data derived from the university's online learning platform, this study tests the model, and then examines the instructor' activities, students' activities and interaction activities among the instructor and students, as well as the relationship between those activities. SEM has the potential to analyze relationships between manifest variables (directly measured or observed, indicator) and latent variables (the underlying theoretical construct).

## 4. Latent variables identified

This study collected data of 16 indicators of instructors' and students' online activities, in which six of them focus on the instructor's role on students' learning; ten of them are close to students' learning activities.

As illustrated in the role of instructor literature, teaching presence includes instructional design, organization, facilitating discourse and direct instruction components (Anderson, Rourke, Garrison, & Archer, 2001). Shea, Li and Pickett (2006) clustered teaching presence items into two categories that interpreted as Instructional Design and Organization and Directed Facilitation. Among the six indicators of instructor's role on students' learning, three of them refer to setting up clear course goals and requirement, building curriculum materials and providing course instruction, similar to the description of Instructional Design and Organization component (Shea, Li and Pickett, 2006). According to that, those three indicators are clustered into one factor called "preparation activities by instructor", which focuses on designing and planning course content and learning activities. The other three indicators are related to keeping students on track, and diagnosing students' misperceptions, similar to the description of Direct Facilitation component (Shea, Li and Pickett, 2006). Therefore, those three indicators are clustered into one factor called "guidance and assistance activities by instructor", which emphasizes assistive role of the instructors in offering instructional support to students.

In the student engagement literature, most benchmarks or indicators that measure students' engagement emphasizes students' preparation for the study, making reflection on what they have learned, and interaction with their instructors and peers. Robinson and Hullinger (2008) modified four benchmarks of NSSE to evaluate student engagement level in the online learning environment. Among them, "level of academic challenge" primarily measures the academic effort students are spending on reading, writing, preparing for their study, and working on their assignments. "Student–faculty interaction" and "active and collaborative learning" refer to students having discussion with their academic faculty about reading, class notes, grades or assignment, and career plans, receiving prompt feedback from faculty, as well as working with other students. In terms of the ten indicators about student activities in our study, six of them are close to the level of academic challenge, in which three of them refer to activities students view and understand learning materials, thus clustered into one factor called "viewing activities by students"; the other three are related to students completing learning tasks and making learning reflection activities, and categorized to one factor called "completing learning tasks activities by students". The remaining four indicators are close to the benchmarks of student–faculty interaction as well as active and collaborative learning in Robinson and Hullinger (2008), which could be clustered into one factor called "interaction for learning".

**Table 2**
Correspondence of latent variables and manifest variables.

| Teaching and learning activity factors (latent variables) | Indicators (manifest variables) |
|---|---|
| Preparation activities by instructor | The number of instructors entering the course, posting course notification, and uploading learning materials |
| Viewing activities by students | The number of students entering the course, viewing course notification, and viewing learning materials |
| Guidance and assistance activities by instructor | The number of instructors identifying and presenting FAQs of the course, administering course questionnaire, and administering assignments |
| Completing learning tasks activities by students | The number of students completing course questionnaires, making reflection notes, completing and uploading assignments |
| Interaction for learning | The number of students posting topics, responding to discussion posts, replied by instructors and other students in the discussion forum; students asking questions |

To summarize the above analysis, this study constructed five factors (latent variables) about instructor's activities and students' engagement activities in the online learning environment. Two types of instructor's activities include course preparation, and guidance and assistance activities; three dimensions of students' engagement activities involve viewing and completing learning tasks, as well as interaction for learning. Among three factors regarding students, viewing and completing learning tasks stress individual aspect, while interaction activity is group collaborative knowledge construction dimension. The correspondence between these latent variables and manifest variables are shown in Table 2.

## 5. Research questions and hypotheses

In the online learning environment, instructors, learners and environment are the key factors that influence the learning process and effect. Among them, the instructor is the core factor, directly affecting the behavior of the students and interaction between the instructors and learners (Clark, 1993). As stated in the critical analysis of the extant literature above, instructor's teaching presence, such as design and teaching approach, plays a vital role in the adoption of a deep approach to students' learning. When the instructors provide effective instructional design, organization, and active guidance, students display higher levels of learning community, and deep levels of critical inquiry (Bangert, 2008; Garrison & Cleveland-Innes, 2005; Shea, Li, & Pickett, 2006).

The instructors should design appropriate learning activities to stimulate learners' higher level cognitive activities (Dunlap, Sobel, & Sands, 2007; Jensen, 1998). Only when the instructors have designed high quality of teaching materials and activities, and provided learners with immediate feedback and support, can learner–content and instructor–student interaction be effective.

Based on the above literature, the instructors have a positive impact on students' learning. In this study, we have obtained two types of instructor activities and three dimensions of student engagement. In order to examine how different types of instructor activities affect student engagement, six research hypotheses are proposed below:

**Hypothesis 1 (H1).** Instructor's course preparation positively affects students' viewing activities;

**Hypothesis 2 (H2).** Instructor's teaching guidance and assistance positively affects students' completing learning tasks activities;

**Hypothesis 3 (H3).** Instructor's course preparation positively affects students' completing learning tasks activities;

**Hypothesis 4 (H4).** Instructor's teaching guidance and assistance positively affects students' viewing activities;

**Hypothesis 5 (H5).** Instructor's course preparation positively affects students' interaction for learning;

**Hypothesis 6 (H6).** Instructor's teaching guidance and assistance positively affects students' interaction for learning;

Moreover, for the purpose of investigating the relationships among the three dimensions of student engagement, we have another five hypotheses:

**Hypothesis 7 (H7).** Students' viewing activities positively affects their completing learning task activities;

**Hypothesis 8 (H8).** Students' viewing activities positively affects their interaction for learning activities;

**Hypothesis 9 (H9).** Students' interaction for learning positively affects their viewing activities;

**Hypothesis 10 (H10).** Students' completing learning tasks activities positively affects their interaction for learning;

**Hypothesis 11 (H11).** Students' interaction for learning positively affects their completing learning task activities.

The hypothesis model is shown in Fig. 1.

## 6. Main findings: constructing teaching and learning interaction activities model

Through the above description of latent variables and manifest variables, this study employed structural equation model analysis software AMOS 17.0 to have exploratory specification search which can explore the relationships between pairwise variables in the hypothesis model to find the appropriate SEM model. When doing exploratory specification search, AMOS automatically compares each path in the model, forms a number of identifiable path combination hypothesis model, and makes model fitting test using the sample data. After making the exploratory specification search, the best-fit model and the results (standardized estimates) returned by AMOS is demonstrated Fig. 2.

Five hypotheses remained (H1, H2, H5, H7, H10), and all of them are positively significant at the level of 0.001. However, for Hypothesis 5, that instructor's course preparation has a negative impact on students' interaction for learning is unreasonable according to the above

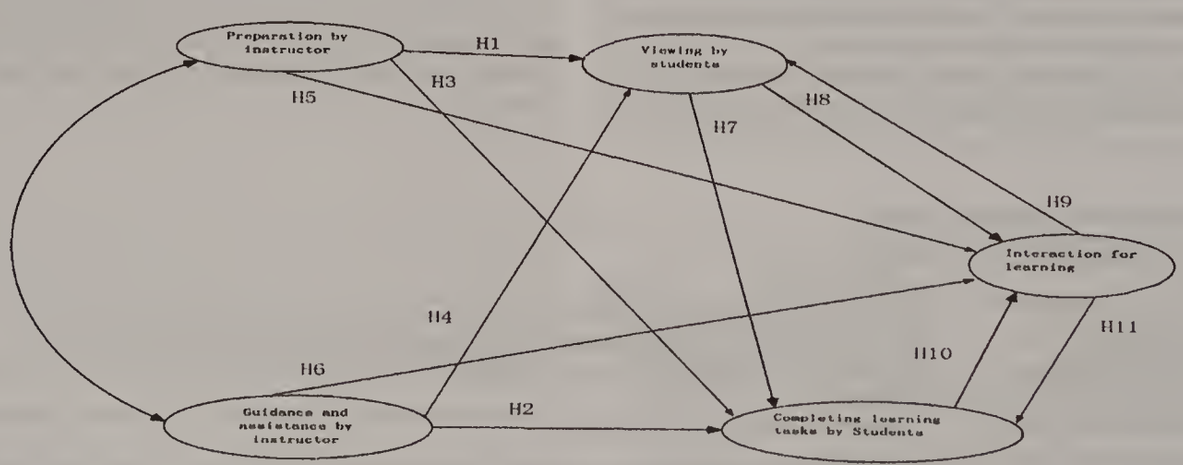


Fig. 1. Research hypothesis model.

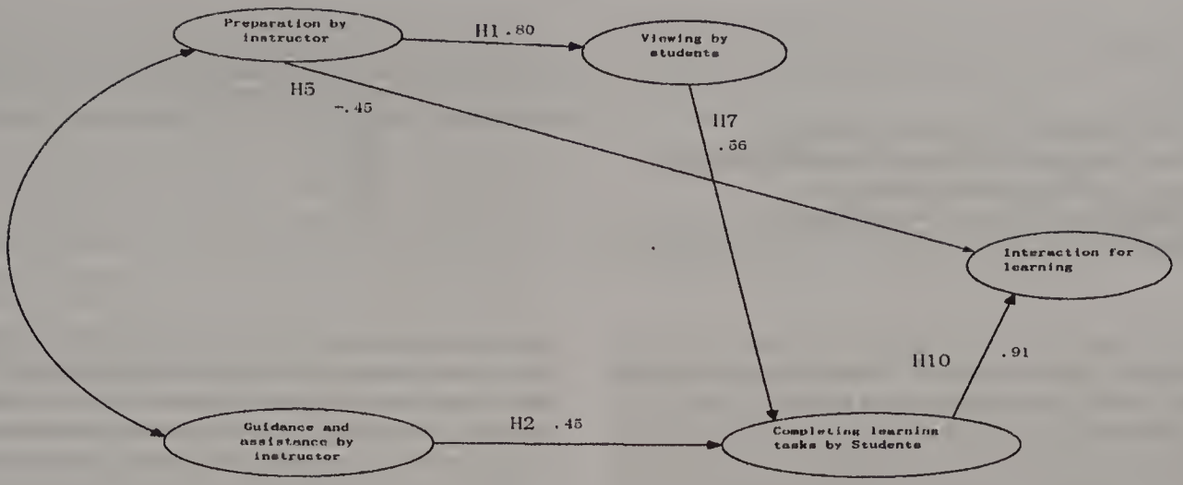


**Fig. 2.** Model after exploratory specification search.

literature about the instructor's role. Thus, we further modified the model, deleting H5. The modified model and the results are shown in Fig. 3.

To assess how the hypothesized modified model fits the measured data, this study used several important goodness-of-fit measures. In this test, $\chi^2 = 671.072$, df = 89, $p < .01$. The $\chi^2$ is not too small, because of the large samples (900). Other goodness-of-fit measures, goodness of fit index [GFI] = .914; normed fit index [NFI] = .919; comparative fit index [CFI] = .929; root mean square error of approximation [RMSEA] = .085; root mean residual [RMR] = .043.

Those values indicated a good fit between the model and the observed data. The hypotheses results are demonstrated in Table 3.

In this study, the four hypotheses are positively significant at the level of 0.001, thus the results indicate support for all the four hypotheses (H1, H2, H7, H10).

For Hypothesis 1, instructor's course preparation is significantly positively related to students' viewing activities (β = 0.80). The more instructors prepare the courses, the more students have viewed related learning content. Specifically, for the three measured indicators that impact instructor's course preparation activities, the most important influence indicator is the number of instructors entering the course (0.85), the second one is posting of the course notification (0.76), and the third is uploading learning materials (0.51). This result indicates that designing and preparing course materials is a critical activity of instructor's course preparation. For the three measured indicators that impact students' viewing activities, the most important influence indicator is the number of students entering the course (0.88). The second one is viewing course notification (0.79), and then viewing learning materials (0.68). The results demonstrate that an instructor entering an online learning platform is the basis of the preparation for the course, and then directly influences students' viewing course materials.

For Hypothesis 2, instructor's guidance and assistance has a positively significant impact on students' completing learning task activities (β = 0.40). The more instructors provide guidance and assistance to

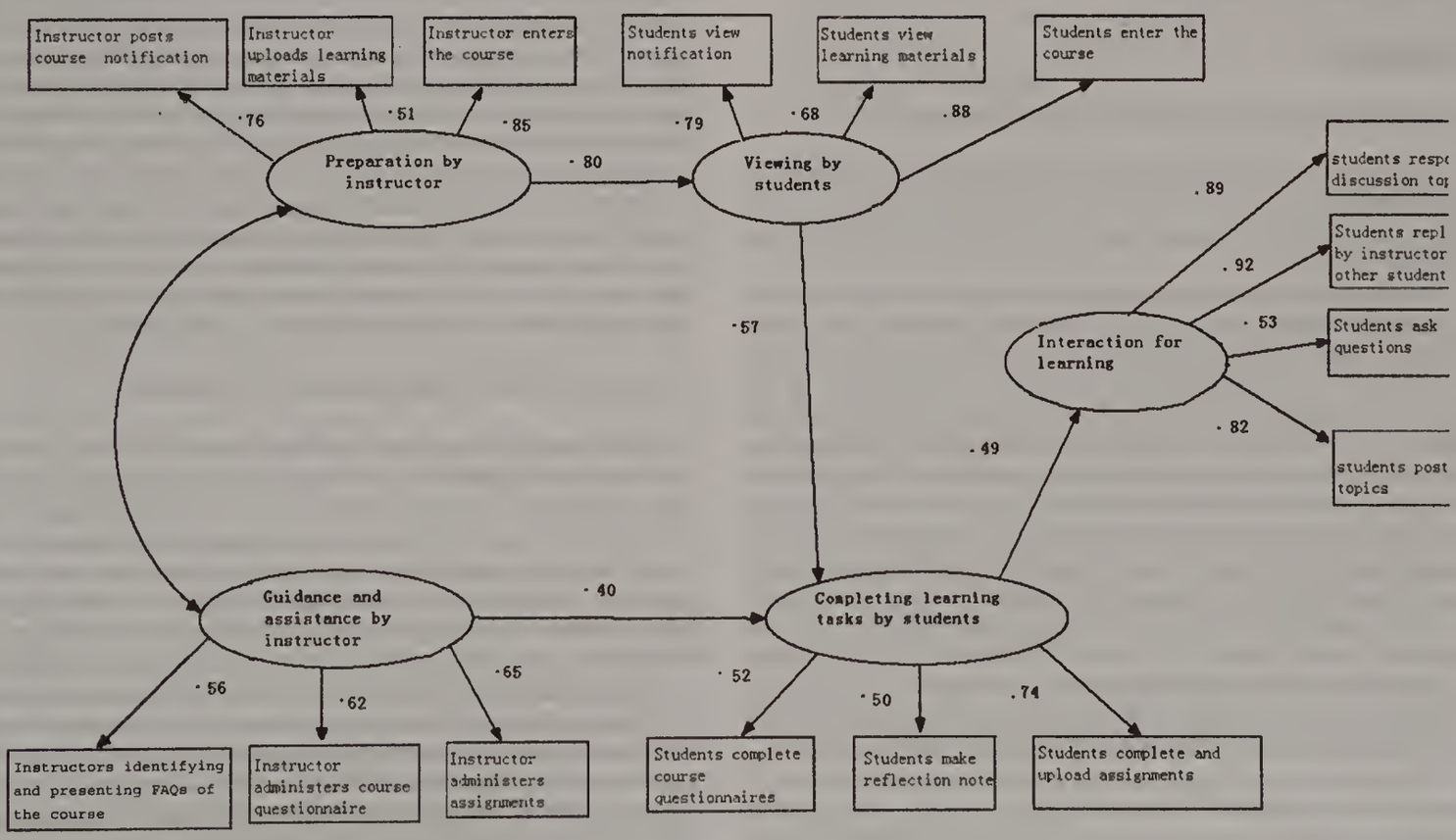


**Fig. 3.** Teaching and learning interaction activity model.

**Table 3**
Research hypotheses results.

| Research hypotheses | Standardized estimates β | Results |
|---|---|---|
| H1: Instructor's course preparation → students' viewing activities | .80*** | Support |
| H2: Instructor's guidance and assistance → students' completing learning tasks | .40*** | Support |
| H7: Students' viewing → students' completing learning tasks | .57*** | Support |
| H10: Students' completing learning tasks → interaction for learning | .49*** | Support |

*** Indicates $p < 0.001$.

students, the more students could complete their tasks. Thus, if the instructor would like to improve students' completing more learning tasks, they need to offer more assistance to students. Specifically, administering assignments plays the most critical role in the instructor's guidance and assistance activities (0.65), while completing and uploading assignments (0.74) dominates students' completing learning tasks, making reflective notes (0.50) and completing course questionnaire (0.52) are also vital learning activities.

Comparatively, the influence of instructor's course preparation on students' viewing ($\beta = 0.80$) is stronger than that of instructor's guidance and assistance on students' completing learning tasks ($\beta = 0.40$). This result demonstrates that the instructor's preparation activities can more easily enhance students' viewing activities; while the impact of instructor's assistance activities on students' completing learning tasks is weaker.

For Hypothesis 7, students' viewing activities directly exerts a positive influence on their completing learning task activities. This hypothesis is supported indicating that the more students view learning materials and content related to the online course, the more they have completed learning tasks ($\beta = 0.57$).

The supported Hypothesis 10 demonstrates that the students' completing learning tasks exert direct positive influence on students' interaction for learning ($\beta = 0.49$). For the specific indicators that influence interaction for learning activities, students' activities in the discussion forum, such as actively posting topics, responding to others' questions and replied by instructors and peers, are the most important influence indicators.

## 7. Discussion

### *7.1. The impact of instructor's role on students learning activities*

This study makes a comprehensive investigation and examines more dimensions of the instructor's and students' activities, as well as more specific relationships among those activities compared with the previous studies.

The findings of this study reveal that instructor's course preparation activities positively affect students' viewing activities (H1), while instructor's guidance and assistance activities have significant impact on students' completing learning tasks (H2). With respect to the instructor's guidance and assistance activities, the critically influential indicator is the instructor administering assignment; administering course questionnaire and identifying and presenting FAQs students are facing in the course also dominate the guidance activities. It seems that the nature of the learning task assigned to students is a key factor that determines the level of student engagement; receiving suggestions and feedback from the instructor is also vital for students' involvement in course learning. The findings are consistent with the previous researches that the quantity of assignment and students' level of learning approach depends on whether the task and materials can lead to students' higher level of learning and instructors' prompt assistance (Garrison & Cleveland-Innes, 2005; IUCPR, 2003; Ramsden, 1992).

The results of this study also show that the impact of instructor's preparation on students' viewing (0.80) is greater than that of instructor's guidance and assistance on students' completing learning tasks (0.40), indicating that instructor administering assignments and course questionnaires, and presenting FAQs are not yet fully guaranteed that students' completing learning tasks activities occur. Thus, instructors should understand students' characteristics and real learning needs, further improve instructional design on teaching assistance and guidance, in order to enhance students' active learning reflection, and help students to improve their cognitive process from lower level to higher level (Anderson & Krathwohl, 2001).

Moreover, the students' completing learning tasks have direct positive impact on their interaction for learning activities ($\beta = 0.49$). Although students' viewing activities have no direct impact on their interaction activities, the viewing activity has an indirect influence on the interaction activity ($\beta = 0.28$), demonstrating that both of them can impact interaction for learning. Therefore besides emphasizing guidance and assistance, the instructors still cannot ignore course preparation and design of the learning content. And in order to promote interaction activities, such as posting on the discussion forum, asking questions to instructors, students should make deep and sufficient interaction with learning content including completing the questionnaire, making learning note and reflection, etc. Furthermore, it might be concluded that effective student engagement cannot simply only depend on instructors sending course materials, but instructors' assistance and prompt feedback would be required to help students make learning reflection and actively participate in course discussion (Garrison & Cleveland-Innes, 2005).

Overall, the findings of the study reveal the importance of instructor's role on student engagement in the online learning environment. The role of instructor is not only limited to elaborately designing curriculum materials and preparing for the course, but also extends to focusing on using a variety of methods and tools to design and plan effective learning activities to enhance students' learning, and providing process guidance and assistance, so that students have greater participation in interaction activities, and more positively engage in their academic work. In other words, the results demonstrate that in order to improve students' engagement in learning activities, the instructors should pay a high degree of attention to design appropriate materials and activities which can enhance instructor–students interaction (Robinson & Hullinger, 2008), as well as monitor students' learning processes, discover students' learning difficulties immediately and provide timely feedback.

### *7.2. Compared with Community of Inquiry (COI) literature*

In the study of Garrison, Cleveland-Innes and Fung (2010), they have investigated the relationship of teaching presence, cognitive presence and social presence using the SEM method. Based on the survey data, they proposed that teaching presence plays a central role in establishing and facilitating cognitive and social presence; while social presence could be seen as a mediating variable between teaching and cognitive presence. In our study, instructor's role directly influences two dimensions of students' engagement activities (viewing and completing learning tasks), while indirectly affects students' interaction for learning through the viewing and completing learning tasks. Cognitive presence emphasizes critical thinking and four phases of inquiry process, including triggering event or communication, exploration in search for information and knowledge, integration ideas, resolution of the issue or problem (Garrison, Anderson & Archer, 2000). Comparing with the data about

cognitive presence they obtained from survey, in our study, data about students' viewing and completing learning task captured from log data using learning analytics represent more objective of the students' activities. As for the social presence, emotional expression, open communication and group cohesion are three categories in this presence. The social presence emphasizes emotions, respectful attitudes, and a sense of group commitment in a supportive context for educational process (Garrison, Anderson & Archer, 2000). Similarly, data acquired by Garrison et al. are still based on more subjective information; in our study, interaction for learning focuses on the more authentic "activity". Thus, using learning analytics approach, the researchers could obtain more objective, direct and authentic data which reflects the measurable relationship among the instructor and learner behaviors; while using the survey or questionnaire the researchers could get more subjective information that may examine the cognitive and emotional issues in the man-mind.

Moreover, comparing the cognitive presence and the students' activities in our study, whether those activities reflect inquiry process should depend on the specific activities. For example, for the activity of students' completing assignments, our study used the number of operations of this activity; whether students' completing assignment activity could be included in the cognitive presence depends on the nature of the assignments and how the students completing the assignments. Further research should be carried out to investigate more specific aspects about the viewing, completing learning tasks activities and interaction for learning activities, and the relationships among instructor's and students' activities.

## 8. Conclusion and further research

This study builds a robust, empirically generated teaching and learning interaction activity model that shows clearly how the instructor's course preparation and assistance activities affect different dimensions of student engagement activities. Through examining interaction between instructor, student and learning content, it also shows the relationship among these engagement activities as the necessary condition to improve student learning in one university's online learning environment.

Compared with the body of researches that examine student engagement in the online environment (Coates, 2007; Richardson & Newby, 2006; Robinson & Hullinger, 2008; Sun & Rueda, 2012), this study investigates instructor's impact on student engagement more directly and comprehensively. Moreover, instead of using traditional survey or questionnaire data collection methods, this study uses a learning analytics approach to gain greater insight from a large amount of data automatically obtained by an online learning system. Compared with the studies using learning analytics approach to examine student engagement in the online environment (Beer, Clark & Jones, 2010; Phillips et al., 2010; Rahman & Dron, 2012), this study examines instructors' activities in a more nuanced way, and considers more aspects and dimensions of the instructors' and students' activities in the online learning environment.

A main limitation of this research is that there are 16 specific indicators used to represent five types of teaching and learning activities; that is probably different from the activities defined by other engagement topic researches. Further researches should analyze additional indicators to explore instructor's impact on student engagement. Moreover, this study adopts the whole data in one university, more studies need to be conducted to examine other situations and have comparison between different universities. Furthermore, this study has examined the necessary level of engagement, future researches need to explore the specificity of student activities to investigate student engagement. Finally this study has been confined to the university sector, yet there is a reason to apply the model to the online learning environment that is being developed with increasing complexity in elementary and secondary education.

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# Wikis and forums for collaborative problem-based activity: A systematic comparison of learners' interactions

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ABSTRACT

This article describes an experimental study that evaluated differences in students' discourse and actions when they used a wiki with discussion (i.e., an enhanced wiki) vs. a forum with attached MS Word documents for asynchronous collaboration on two case problems. The study used a counterbalanced within-subject design with 34 online learners working in small groups. A systematic content analysis of learners' interactions coupled with visual, analytical techniques showed within-group differences in using the technologies. The study revealed the expanding nature of a forum and the condensing nature of a wiki. Also, findings suggest that in a wiki, groups tend to be more collaborative, whereas in a threaded discussion, groups tend to be more cooperative. The study provides insights for instructors who use wikis and forums in their online courses to support collaborative problem-based activity.

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## 1. Introduction

With the rapid expansion of Web 2.0 technologies, institutions worldwide have recognized e-learning as a viable alternative or supplement to traditional, face-to-face instruction (Allen & Seaman, 2011). Meanwhile, teamwork and collaboration are key competencies which higher education institutions should actively help their students develop (National Research Council, 2012). This claim has been made, in part, because problems faced by today's professionals are often multi-faceted and require group rather than individual solutions. As such, many instructors practice social constructivist pedagogy (Palincsar, 1998) in their online courses, encouraging collaborative work among learners and engagement with knowledge-building practices. Particular interest has been given to problem-based instructional methods in small groups–such as the case method–that situate learning in meaningful tasks and emphasize the importance of practical experience in learning (Derry, Hmelo-Silver, Nagarajan, Chernobilsky, & Beitzel, 2006; Dottin & Weiner, 2001; Hmelo-Silver & Chernobilsky, 2004). In practice, such methods involve participation in shared activities, including decision making and negotiation of ideas, all organized into a learning environment supported by (Web 2.0) technologies.

Forums and wikis are widely employed in e-learning settings to support social constructivist pedagogy. These technologies made their way into online learning more than a decade ago and there is a dearth of research discussing their effectiveness and limitations. From a theoretical perspective – in this case, a social constructivist perspective – tools play an important role in extending human abilities and enhancing thinking processes (e.g., as in helping to explicate one's thoughts). Although researchers generally agree that wikis and forums are framed by social constructivism, there is a need to further theorize the relationship between tasks, tools and collaborators in computer-supported collaborative learning settings (Lund & Rasmussen, 2008). Furthermore, there is a need for more research examining differences between such tools and exploring how they might be used to serve different learning goals (Kear, Woodthorpe, Robertson, & Hutchison, 2010). The present study focuses on the latter, echoing the view of many researchers that different types of computer supports afford different opportunities for collaborative learning (e.g., Hmelo-Silver, Chernobilsky, & Nagarajan, 2009; Suthers, Vatrapu, Medina, Joseph, & Dwyer, 2008). In particular, this study aims to systematically assess differences in students' interactions when they use a wiki with discussion (i.e., an enhanced wiki) vs. a forum with attached MS Word documents for asynchronous collaboration on case problems.

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### 1.1. Online threaded discussion (or threaded discussion, or forum)

Threaded discussion captures the exchange of messages over time, organized in categories and grouped in threads (i.e., messages and responses grouped together). Typically, within a course management system (e.g., Moodle, Blackboard), threaded discussion is the dominant means for enabling dialog and collaboration. The affordances of threaded discussion for (online) learning have been extensively discussed in the literature. In particular, threaded discussion is considered an effective means for engaging learners in knowledge construction and critical thinking (Cheong & Cheung, 2008; de Leng, Dolmans, Jöbsis, Muijtjens, & van der Vleuten, 2009; Richardson & Ice, 2010), promoting participation and diversifying of ideas (e.g., Bruning, 2005; Hammond, 2005; Heckman & Annabi, 2005; Lapadat, 2004), enabling learners to reflect on peers' contributions and analyze their own ideas before articulating them, therefore improving the quality of their postings/overall discussion (Browne, 2003; Pena-Shaff & Nicholls, 2004), and facilitating learners' meta-cognitive awareness and development of self-regulatory processes and strategies (Vonderwell, Liang, & Alderman, 2007), among other benefits.

Despite the research on effective uses of threaded discussion, the technology is also associated with problems pertinent to collaborative learning. In particular, it has been characterized as lacking coherence and offering weak support for online collaborative knowledge construction (e.g., Eryilmaz, Ryan, Van der Pol, Kasemvilas, & Mary, 2013; Herring, 1999; Hewitt, 2001, 2003; Suthers et al., 2008). For instance, Hewitt (2001) examined graduate students' use of threaded discussion in three different online courses at the University of Toronto. His analysis revealed that students rarely engaged in convergent processes; virtually all messages were "add-on notes" (built on the ideas of another post in the thread), and only a few students attempted to tie together ideas from different posts. Other researchers explained that the tree/hierarchical structure imposed by standard threaded discussion tools – every contribution is connected to a parent note and leads to several other child notes – is too restrictive for collaboration (e.g., dePaula, 1998; Stahl, 2001). Specifically, Stahl (2001, 2006) argued that in order to bring several ideas together in a summary or synthesis, the technology should allow a particular contribution to be tied to several parent notes (see WebGuide interface in Stahl, 2001, 2006). He further advised that collaborative learning technologies should distinguish those features aimed to support discussion from those aimed to support collaborative knowledge construction, in a way that discussed ideas can be integrated into knowledge construction processes (Stahl, 2006). Similarly, others have argued that, in typical threaded discussion tools, discussion and group artifacts (e.g., a group document) are disjointed, which is not conducive to online discourse about artifacts (Eryilmaz et al., 2013; Suthers, 2001; Suthers & Xu, 2002). In particular, Suthers (2001) argued that collaborators should be able to carry on a discussion with reference to a visual artifact that they can manipulate; yet, as he explained, in typical learning management systems, discussion tools and shared artifacts are displayed on entirely different screens, which inhibits artifact-centered discourse (Suthers, 2001).

### 1.2. Wikis

Wikis are collaborative editing tools supporting the creation of cohesive artifacts authored by many individuals. In general, four design elements in wikis might support collaboration: 1) The existence of a group-owned document with editing capabilities that necessitates negotiation among participants; 2) The tracking mechanism for modifications to the group-owned document (so called, history documentation); 3) The integration of notification and alert features, which gives users the option of receiving automatic reports when the group-owned document is modified; and 4) The communication supports that are often included, such as discussion pages associated with group-owned documents or commenting features in which collaborators can identify problems, resolve disagreements, and negotiate consensus, before altering content (Marandi & Nami, 2013). Morgan (as cited in Bruns & Humphreys, 2005) argued that a wiki with discussion (i.e., an enhanced wiki) serves "a kind of ongoing meta-analysis on the part of the authors," as collaborators move from discussion-mode (informal arguments) to document-mode (formal arguments), and vice versa (p. 28).

There is a substantial body of research showing the positive effects of wiki use in e-learning settings. For example, wikis have been found to enhance peer interaction and sharing of knowledge among participants in groups projects (e.g., Augar, Raitman, & Zhou, 2006; Boulos, Maramba, & Wheeler, 2006), to support the co-writing (e.g., TREnTIn, 2009), and to make the group task highly motivating (Wheeler, Yeomans, & Wheeler, 2008) among other benefits. In the past 15 years, wikis have been successfully used to support collaborative production of artifacts and learning resources, project planning in student teams, online debate, peer-review activities, and preparation of ePortfolios (e.g., Augar et al., 2006; Bruns & Humphreys, 2005; Forte & Bruckman, 2006, 2007; Ioannou & Artino, 2008, 2009; Lamb & Johnson, 2007).

Yet, barriers to the implementation of wikis exist. For example, previous studies have discussed issues such as that making a wiki available does not ensure students will work *together* as the functional affordances of the tool for supporting collaborative learning are not always perceived and utilized by the students (e.g., Choy & Ng, 2007; Ioannou & Artino, 2008), users are often reluctant to edit each other's work (e.g., Dalke, Cassidy, Grobstein, & Blank, 2007; Ioannou & Artino, 2009), and for a wiki implementation to be successful, scaffolding and instructor facilitation are required (e.g., Foley & Chang, 2008; Ioannou & Artino, 2009), together with carefully designed learning tasks demanding negotiated meaning and group interdependency (e.g., Bower, Woo, Roberts, & Watters, 2006; Ioannou & Artino, 2009). Despite the considerable adoption of wikis in education, evidence of their benefit as collaborative learning tools is equivocal to date.

Wikis and forums to support collaborative learning present online instructors with opportunities, but they also present several dilemmas. Both come with pros and cons in supporting social constructivist pedagogies and collaborative problem-based activity. Considering their wide adoption, coupled with the inconclusive research evidence, the present study sought to compare them systematically, as learners used them to collaborate virtually on case problems. There are very few experimental studies in the literature comparing these technologies, and when available, these studies compare different groups of learners using either wiki or threaded discussion (e.g., Ioannou, 2011; Ioannou & Artino, 2009; Vasquez & Potter, 2013; Wicks, Ellis, & Lumpe, 2013). The present study is unique in its design, assessing learners' use of *both* technologies (i.e., a within-subjects design) in the context of collaboration on case problems.

## 2. Method

### 2.1. Participants

The participants were 34 graduate students in two sections of an online course on learning theories, taught over 16 weeks at a public university in Northeast USA. The participants of Section 1 ($n = 20$) pursued a Master of Arts (MA) in educational technology; 90% of these students were in-service teachers. The participants of Section 2 ($n = 14$) pursued a MA in educational leadership; all of these students were in-service teachers. The complete sample ($n = 34$) included 79% women (21% men) between 22 and 54 years of age ($M = 37$, $SD = 10.8$). Each section was taught by a different instructor; however both instructors used the same procedures for the investigation as well as the same weekly activities and pedagogy throughout the course. Students completed all activities associated with this investigation as part of their class work.

### 2.2. Technologies

The wiki for the study was created in MediaWiki — the open-source platform originally written for Wikipedia. The wiki provided a group-owned document with editing capabilities, a (wiki-type) discussion page associated with each document in which collaborators could negotiate consensus, history documentation, and alert features. Writing in MediaWiki pages requires learning its markup language, which is a simplified alternative to HTML. However, for the purpose of this study, a freely available WYSIWYG (what you see is what you get) add-on editor was installed to simplify the editing process and allow students to focus their attention on the activity.

The forum used in the study was the discussion board within Blackboard WebCT, where MS Word documents can be attached within threads. In general, all students had experience with the forum, via other university courses. A few participants (roughly 25%) had used a wiki before in another university course (mostly, WikiSpaces). However, the study allowed several weeks of interaction with both tools through weekly, class-wide activities, before the investigation begun (see procedures).

### 2.3. Case problems

The case method is a problem-based instructional method that requires students in small groups to work on real-world problems that are complicated and messy. Research suggests this problem-based approach is an effective method for adult learners, including in-service and pre-service teachers (Dottin & Weiner, 2001; Merseth, 1991). Two case problems were used in this study (Case A and Case B). To ensure quality, both cases were taken from books which specialized on the case method for teacher education. Case A was taken from Dottin and Weiner (2001); it concerned a 12-year old boy with low self-esteem and bad academic performance, but whose test results suggest he is capable of better achievement. Case B was taken from Greenwood, Fillmer, and Parkay (2002); it presented a "divided" class in which 2/3 of students read at grade level (and find the class readings "boring"), while the remaining 1/3 are reading 2–3 years below grade level and are very frustrated by having to read beyond their independent reading levels. In both cases the question for students in the present study was — How can learning theory inform the problem presented in the case and guide the teachers involved?

The case problems were carefully selected by three educational psychology experts, who agreed on the equivalency of the cases in terms of complexity. Also, the three experts developed an evaluation rubric for the final group essay, which was provided to the students. Students were to apply concepts learned in the course, as well as their professional practice, and suggest plausible solutions to the case problem. Each group was instructed to draft their consensus solution(s) in the form of an essay. In order to guide their activity, students were provided with guidelines on how to approach the analysis of the case problem, adapted again from Dottin and Weiner (2001) (see Table A1 for guidelines for the analysis of the case problem).

### 2.4. Research design and procedures

The study used an experimental design, particularly a within-subject (repeated measures) design with counterbalancing. The strength of the within-subject design is that it allows the researcher to study every single participant (or group) in all treatment conditions (e.g, working with both wiki and threaded discussion). This design takes out the variance due to the individual (or group) differences and increases the likelihood that any differences (e.g., differences in discourse and actions) across conditions are due to the treatment (e.g., wiki vs. threaded discussion) and not the participants (Shadish, Cook, & Campbell, 2002). To avoid confounding carryover effects (Shadish et al., 2002) with the technology effect in this study, the order of treatments was counterbalanced; that is, some groups received the technologies in one order (i.e., wiki first, threaded discussion second), and other groups in reverse order (i.e., threaded discussion first, wiki second). To avoid an instructor-effect, we also mixed groups within treatments (see Table 1) and the instructors' role was deliberately limited to only providing structural feedback (e.g., "You need to base your arguments on instances from the case and to support those with theory") and acknowledging students' contributions (e.g., "This is a good argument ..."). See Table 1 for a visual presentation of the research design.

In the weeks before the investigation (weeks 1–9) students were exposed to both wiki and threaded discussion technologies through weekly, class-wide activities, using the technologies. For example, the wiki was used for an icebreaker activity that asked students to post profiles and pictures, or to build a database of knowledge on some units, or to share notes and reflections on the readings. The threaded discussion was used to facilitate discussions or debates on learning theories. Students did not work on case problems (or other problem-based activities), nor did they work in small collaboration groups, until week 10 when the investigation begun.

During weeks 10–11, students were randomly assigned to groups of 3–4 students to work on Case A. As presented in Table 1, five groups (Group 1) used the wiki for their collaboration on Case A, and four groups (Group 2) used the threaded discussion. During weeks 12–13, the same groups worked on Case B, but this time the technologies were reversed. Students were specifically instructed not to use any other technologies for their collaboration, other than their assigned technology.

Data from students' interactions in the wiki and threaded discussion were collected twice — once at the completion of Case A and once at the completion of Case B. In the forum, data included students' postings on the discussion board and MS Word documents attached in the threads. In the wiki, data included postings on the wiki discussion page and contributions in the wiki group-owned document.

## 3. Analysis and results

The analysis was conducted in two levels: (a) coding and counting the learners' contributions in order to understand differences in the use of the technologies, and (b) exploring the collaborators' contributions as they occurred chronologically, to constitute further evidence for differences in the use of the technologies.

### 3.1. Code-and-count content analysis

Initially, the study adapted a coding scheme developed in previous research by researchers such as Rourke and Anderson (2004) and deWever, Schellens, Valcke, and Van Keer (2006). These authors strongly encouraged the re-use of existing coding schemes to foster study replicability and validity. The Discourse Categories Coding Scheme (see Table A2) was modified from Hmelo-Silver and Chernobilsky (2004), Hmelo-Silver et al. (2009) who studied computer-supported collaborative learning during problem-based activities. It includes four main discourse categories – collaboration, complexity, monitoring & planning, and other content – further broken down into 17

**Table 1**
Counterbalanced order for two groups in a within-subject design.

| | Case A (weeks 10–11) | Case B (weeks 12–13) |
|---|---|---|
| Group 1 (Group 1 consists of 3 groups from Section 1 and two groups from Section 2) | Wiki | Threaded discussion |
| Group 2 (Group 2 consists of 2 groups from Section 1 and two groups from Section 2) | Threaded discussion | Wiki |

subcategories. Additionally, in order to capture the types of interactions evident during the construction of group essays a new coding scheme was created (see Table A3 for Construction Categories Coding Scheme), including four categories — expansion, deletion, content editing, and formatting and spelling. Both coding schemes were pilot-tested in a smaller-scale study in the same context (authors, 2011). Tables A2 and A3 provide details about the coding schemes.

The discourse was coded at the unit of a meaning. Usually posts were long and could be coded for more than one category, such as collaboration and complexity. In this case the post was segmented into smaller units and each unit was assigned to one category. Two coders evaluated the entire discourse independently with acceptable inter-rater reliability — 79% agreement (kappa statistics = 0.65) for segmentation into units and 82% agreement (kappa statistics = 0.67) for coding the units. Disagreements were fully resolved with discussion between the coders. It should be noted that, for a better understanding of learners' evolution of thought, all discourse was coded considering its chronological order, which was easily enabled by the wiki history record as well as the time-stamp in the forum. Furthermore, all MS Word documents attached in the forum were compared (to earlier/subsequent versions) using the "compare function" in MS Word.

After coding, the number of codes within each coding category was counted for each group. Then, using the group as the unit of analysis, we conducted both paired samples t-tests and Wilcoxon signed-rank tests (nonparametric test which can treat data measured on nominal/classificatory scale) to evaluate differences in the number of category codes between wiki and threaded discussion technologies (see Table 2). The results showed statistically significant differences between the technologies during the construction of groups' essays, with large effect sizes (Cohen, 1992). In particular, there were significantly more expansion, deletion, content-editing, and formation & spelling codes in the wiki compared to threaded discussion. Yet, the results did not show significant differences in the content of students' discourse; that is, there were no differences in the number of collaboration, complexity, monitoring & planning, and other content codes in the wiki and threaded discussion.

### 3.2. Participation analysis

Using the group as the unit of analysis, participation was assessed on three measures: (1) number of contributions to the discussion of the case problem, (2) average length of contribution to the discussion (in words), and (3) number of contributions to the group essay. See Table 3 for aggregated measures of participation by group. First, a paired samples t-test was conducted to examine within-group differences across technologies in the total number of contributions to the discussion of the problem. As shown in Table 4, on average, groups contributed statistically significantly more discussion postings when they used threaded discussion, compared to wiki, with a medium effect size (Cohen, 1992). Second, a paired sample t-test was conducted to examine within-group differences in the average length of contributions to the discussion of the problem, across technologies; no statistically significant differences were found in this case.

Third, a paired sample t-test was conducted to examine within-group differences across technologies in the total number of contributions to the construction of the group essay. As shown in Table 4, on average, groups contributed statistically significantly more frequently to the group essay when they used wiki, compared to threaded discussion, with a large effect size (Cohen, 1992).

Last, a series of Chi-square-goodness-of-fit tests were conducted to assess whether the technology promoted equality of participation within groups, in terms of number of contributions to the discussion of the case problem and number of constructions to the group essay. The tests showed that within group participation was statistically significantly different in the majority of the groups in both technologies (Chi-square values between 8.2 and 60.9 with p-values < .05 or .001). Only two groups constituted an exception to this, demonstrating equivalent participation in both wiki and threaded discussion. As such, equality of participation appeared to be an attribute of the groups, rather than an affordance of the technology.

Overall the results of the participation analysis reveal the expanding nature of a threaded discussion and the condensing nature of a wiki. In particular, groups produced more discussion postings in threaded discussion, compared to wiki. Yet, as evident from the 'code and count' content analysis, the nature of their discourse did not differ; that is, groups produced roughly as many collaboration, complexity, monitoring & planning, and other content codes in the wiki as in the forum. On the other hand, the wiki was associated with more constitutions to the group essay, which is fully consistent with the findings of the 'code and count' content analysis.

### 3.3. Visual, chronological analysis

For an in-depth examination of within group collaboration, we plotted all discourse and actions on a chronological visual — a method inspired by Hmelo-Silver et al. (2009). That is, for each group, we generated a spreadsheet scatter-plot using the groups' coded discourse and actions. The time of the contribution is plotted at the top of the visual in chronological order (e.g., 2-weeks duration of the activity in 2-days

**Table 2**
Coding and counting — Results of the comparison between wiki with discussion vs. forum with attached MS Word documents.

| | Wiki | Threaded discussion | t-Test statistics (Effect size) | Wilcoxon signed-rank test statistics |
|---|---|---|---|---|
| | M (SD) | M (SD) | | |
| Collaboration | 39.7 (26.8) | 49.2 (24.8) | $t(8) = 0.6, p = .591$ | $Z = .42, p = .678$ |
| Complexity | 16.4 (10.5) | 14.8 (8.0) | $t(8) = 1.6, p = .151$ | $Z = 1.48, p = .139$ |
| Monitoring & planning | 10.0 (8.0) | 14.2 (11.2) | $t(8) = 1.5, p = .182$ | $Z = 1.42, p = .154$ |
| Other content | 17.1 (9.7) | 33.9 (27.5) | $t(8) = 2.3, p = .050$ | $Z = 1.68, p = .092$ |
| Expansion | 12.8 (8.1) | 3.0 (1.0) | $t(8) = 3.2, p = .016^*$ (Cohen's d = 1.70) | $Z = 2.20, p = .028^*$ |
| Deletion | 3.6 (3.5) | 0.1 (0.4) | $t(8) = 3.0, p = .020^*$ (Cohen's d = 1.41) | $Z = 2.02, p = .043^*$ |
| Content-editing | 10.3 (5.3) | 2.5 (2.0) | $t(8) = 4.2, p = .004^*$ (Cohen's d = 1.95) | $Z = 2.39, p = .017^*$ |
| Formatting & spelling | 4.8 (2.1) | 1.8 (1.8) | $t(8) = 2.9, p = .027^*$ (Cohen's d = 1.53) | $Z = 2.25, p = .024^*$ |

* Statistically significant result at .05 alpha level.

**Table 3**
Group participation — Results of the comparison between wiki with discussion vs. forum with attached MS Word documents.

| | #Contributions to discussion | | Average length of contributionto discussion | | #Contributions to group essay | |
|---|---|---|---|---|---|---|
| | Wiki | Threaded discussion | Wiki | Threaded discussion | Wiki | Threaded discussion |
| Group 1 | 102 | 166 | 307 | 386 | 48 | 22 |
| Group 2 | 80 | 105 | 405 | 349 | 48 | 3 |
| Group 3 | 70 | 115 | 293 | 356 | 40 | 7 |
| Group 4 | 70 | 98 | 468 | 397 | 45 | 1 |
| Group 5 | 128 | 159 | 451 | 568 | 42 | 12 |
| Group 6 | 46 | 49 | 283 | 351 | 14 | 6 |
| Group 7 | 5 | 47 | 329 | 546 | 31 | 4 |
| Group 8 | 28 | 25 | 421 | 799 | 16 | 5 |
| Group 9 | 51 | 53 | 364 | 361 | 9 | 7 |
| Means | 64 | 91 | 369 | 457 | 33 | 7 |

**Table 4**
Participation analysis — Results of the comparison between wiki with discussion vs. forum with attached MS Word documents.

| | Wiki | Threaded discussion | t-Test statistics (Effect size) |
|---|---|---|---|
| | M (SD) | M (SD) | |
| Number of contributions (Discussion) | 64.4 (37.3) | 90.8 (50.7) | $t(8) = 3.5, p = .008^{*}$ (Cohen's d = 0.59) |
| Length of contribution (Discussion) | 369 (69.9) | 457.0 (153.7) | $t(8) = 1.9, p = .096$ |
| Number of contributions (Group essay) | 32.6 (15.6) | 7.4 (6.3) | $t(8) = 4.9, p = .001^{**}$ (Cohen's d = 2.47) |

Statistically significant result at:
* .01 alpha level.
** .001 alpha level.

breakdown).[3] The learners and discourse/actions categories are listed on the right of the visual, while each time-point on the visual represents a learner's coded contribution. In general, these visuals are inspected for patterns and serve as pointers to the discourse to help understand the collaboration process, beyond coding and counting. Below, we present the visual of one group working in both wiki (Fig. 1) and threaded discussion (Fig. 2). Although space does not permit the presentation and discussion of more visuals, we generated visuals for all groups, inspected them carefully, and discuss collective results and consistent patterns with reference to Figs. 1 and 2 (all other visuals are available upon request).

First, although within-group participation was unequal, as evident from the chi square tests (i.e., for group 1, $\chi^2 = 8.3$, $p = .040$ for wiki and $\chi^2 = 8$, $p = .046$ for threaded discussion), Figs. 1 and 2 demonstrate that all group members were active throughout the activity in both technologies. This pattern was consistent in the visuals of all groups in both technologies.

Second, Figs. 1 and 2 demonstrate that the group had an early start on drafting their essay using both wiki and threaded discussion. That is, in the wiki the group-owned document was started on the 4th day of the 2-week activity, while in the forum a first draft of the essay was attached on the 5th day. However, this was not a consistent pattern in the visuals of all groups. In almost half of the groups (4 out of 9 groups), the essay was started several days earlier in the wiki, compared to the forum. This observation was further examined through careful inspection of the visuals and associated discourse and actions. We found that, in threaded discussion, discussions were extended in time – consistent with the finding of significantly more discussion postings in the earlier participation analysis – and students started drafting their essays after they had reached consensus on most aspects of the case problem. On the other hand, the wiki group-owned document coupled with the wiki discussion pages enabled the participants to begin working on their essays early in the activity, while they continued to discuss aspects of the case problem.

Relevant to the above is a pattern demonstrated in Figs. 1 and 2 (and associate discourse) concerning the contribution of complex statements. In particular, group 1 produced many and frequent complex statements at the beginning of the task in the wiki. Once the essay was started, complex statements directly evolved as part of the group essay, while other new ideas, elaborations, agreements, disagreement etc. continued to occur in the wiki discussion page. On the other hand, complex statements in the forum were fewer at the beginning, and continued to appear in the threads until later, when they were ready to be copied and pasted in the group's essay (external MS Word document). This pattern of complex statements held true for the majority of the groups and is consistent with the prolonged discussions in the forum and the early start of group essays in the wiki.

Furthermore, Figs. 1 and 2 confirm the findings of the participation analysis in that discussion postings were more frequent on threaded discussion, while contributions to the essay were more frequent in the wiki. Yet, although there were no content differences in students' discourse, the visuals demonstrate a noticeable pattern with regard to 'monitoring & planning' and 'other content' codes. Specifically, it appears that such codes were more frequent in the forum, especially at times when the essay was 'attached' to the threads. This was a consistent pattern across the visuals of all groups and therefore, pointed our attention to the groups' discourse at these particular moments. We found that uploading documents to the threads required some extra coordination (e.g., monitoring & planning) for example: "*I added my piece to what [Name] started yesterday. I named the latest document 11/19 9:31. Who has the token next?*" (group 1, member A). Also, we found that uploading documents to the threads created some frustration about the technology (e.g., other content: tool-related talk), for example, "*After the ease of the wiki, I'm a little unsure of how we're going to pull this off in a threaded board. Don't you think it would be a good idea to use a GoogleDoc? Let's ask the instructor.*" (group 1, Member C).

[3] We note that the 2-day breakdown creates an overlap of the scatters on the visual when contributions are close to each other time-wise (e.g., 1-h apart). This breakdown is unavoidable for the presentation of the visuals in an A4-page, yet the researchers work from a fully-populated visual in spreadsheets where a detailed study of students' interactions is possible.

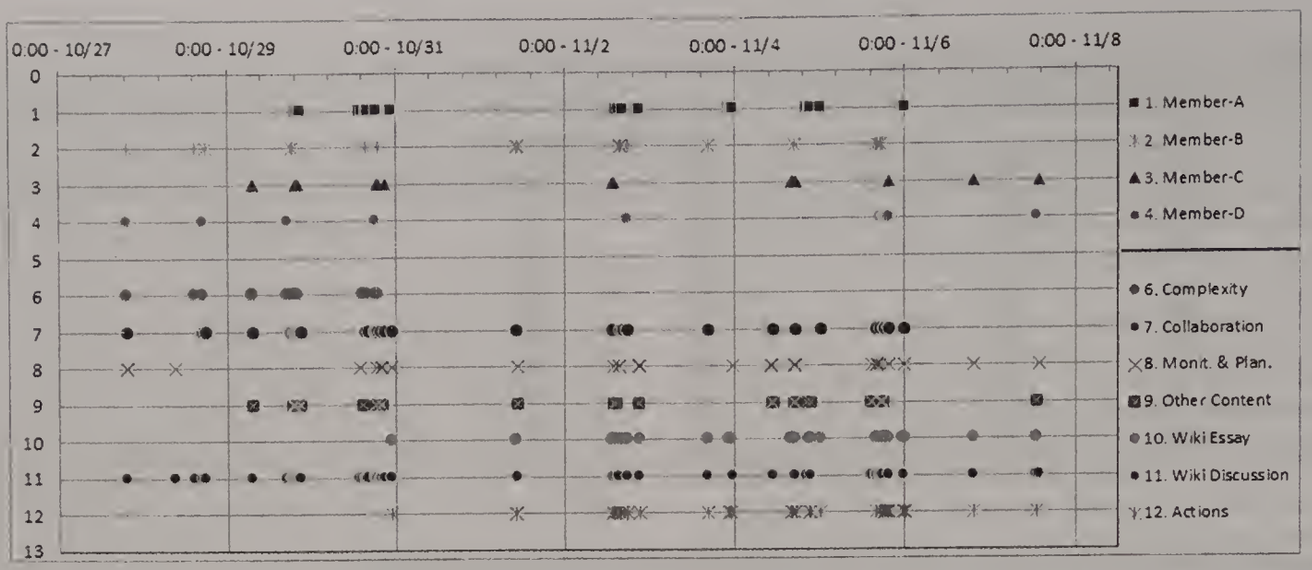


**Fig. 1.** Chronological visual of discourse and actions of group 1 using the wiki with discussion.

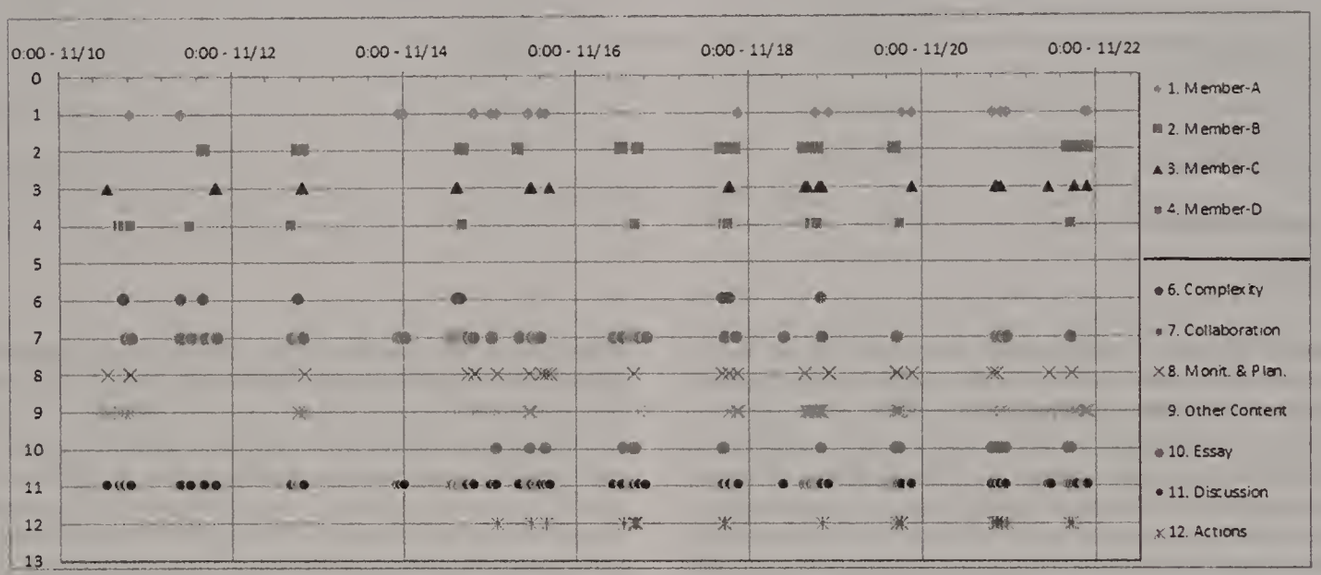


**Fig. 2.** Chronological visual of discourse and actions of group 1 using the forum with attached documents.

Furthermore, our careful inspection of 'monitoring & planning' and 'other content' codes revealed that, in threaded discussion, all groups practiced 'division of labor' for drafting their group essay, for example, "*We should create 3 separate documents and each of us drafts one (Defining the Problem, Facts-Stakeholders, Possible Solutions), then we all review*" (group 6, member A). On the other hand, we found that collaboration in the wiki appeared to be 'smoother' (e.g., "*I started the intro on the article page. I copied and pasted some of our ideas so we can begin to develop a plan. Please feel free to continue editing/adding etc.*", group 1, Member A), and tool-related talk was in the positive direction (e.g., "*Can we add some color to new additions so that we can easily review them?*" group 1, Member D).

## 4. Discussion

The study revealed statistically significant differences in the use of a wiki with discussion vs. a forum with attached MS Word documents for virtual collaboration on case problems with a group essay being the final deliverable. The effect sizes for the statistically significant results were medium to large (see guidelines in Cohen, 1992[4]), indicating that these differences are meaningful and may have practical importance for researchers and users of these technologies (LeCroy & Krysik, 2007).

First, there were significantly more expansion, deletion, content-editing, and formation & spelling actions in the wiki group-owned document compared to MS Word documents attached to the forum. This finding supports prior research findings on wikis, which suggests that wikis can support co-writing (e.g., TREnTIn, 2009). Second, groups produced more discussion postings in the forum, compared to the wiki. Yet, there were no differences in the content of students' discourse in terms of collaboration, complexity, monitoring & planning, and other content. In other words, learners in the forum were more verbose than in the wiki discussion page, but contributed similar content. This finding seems to suggest the expanding nature of threaded discussion and the condensing nature of a wiki with discussion — a finding not systematically documented in the literature thus far.

Moreover, collaboration in the wiki appeared to be easier and more efficient overall. First, in almost half of the groups, the essay was started days earlier in the wiki compared to the forum. We believe that having a discussion page associated with the group-owned document in the wiki enabled this early collaboration on the group essay in coordination with the ongoing discussion — a finding that enforces previous arguments about the need for artifact-centered discourse in online collaborative learning (Eryilmaz et al., 2013; Suthers & Xu, 2002). Nevertheless, although the early start of the essay signals efficiency in students'

[4] Different people offer different advice regarding how to interpret the resultant effect size, but the most accepted opinion is that of Cohen (1992) where 0.2 is indicative of a small effect, 0.5 a medium and 0.8 a large effect size.

collaboration in the wiki, there is no evidence of what might be gained or lost by drafting the essay earlier, rather than later, during the activity. The latter would be interesting to explore in future studies by considering the justifications and level of critical thinking feed into the evolving group essays overtime. Second, it was found that collaboration in the forum required extra effort for the coordination of tasks which often caused frustration evident in students' discourse. This issue became more apparent as threads grew longer and multiple MS Word documents were attached back and forth in the forum. Feelings of frustration were less apparent in the wiki. Last, in the wiki, groups appeared to be more collaborative, working on every piece of the essay together, rather than being cooperative (i.e., sharing the workload), echoing Roschelle and Teasley's (1995) definition of cooperative and collaborative work. Specifically, it appeared that, in the forum, after prolonged (but no richer in content) discussions, different sections of the essay were assigned to different group members to write.

Overall, the differences in the use of wiki and threaded discussion technologies provide insights into how these technologies might support different kinds of student-centered activities. For example, if the task requires the discussion of a topic or a debate on a topic, a threaded discussion tool may be more appropriate (Ioannou & Artino, 2009), as it allows for extended discussions over time. If an (enhanced) wiki is used for the same task, it might enable discussion that is more condensing in nature. However, when the task requires problem analysis coupled with the construction or manipulation of a group artifact, an (enhanced) wiki might be more appropriate than a forum with attached documents in supporting both discussion and group-artifact construction.

Another insight of this work relates to the use of wiki and threaded discussion in combination, enabling the expanding nature of a forum with the condensing nature of a wiki. Perhaps learners and online instructors alike could benefit from using the technologies in some combination or merging them into a more sophisticated tool. Such efforts have been undertaken in a couple of recent studies (Ioannou & Stylianou-Georgiou, 2012; Larusson & Alterman, 2009). In Ioannou and Stylianou-Georgiou (2012), the authors discussed two tools designed to support discussion of ideas 'synched with' the creation of a group artifact. In one case, MediaWiki's discussion page was extended to a fully functional threaded discussion board, while in the other case, a Moodle block was designed to allow the concurrent use of wiki and forum on a single screen. In the same spirit, Larusson and Alterman (2009) presented a wiki enriched with a suite of other tools such as analysis, awareness, and navigation and communication tools. In two case studies the authors demonstrated how this "prefabricated" wiki sufficiently supported collaborative work, although the added value of the new features was not demonstrated in comparison to an un-enhanced wiki. In fact, this was also evident in the present study; the use of history documentation and notification and alert features in the wiki was almost non-existent. That is, the wiki document or discussion was never "reverted" to an earlier version via the history feature, and as we observed from the log file of individuals' actions, the vast majority of the students did not set up email notifications and alert feature. In sum, we would argue that the use of wiki and forum in some combination – 'building' on what each tool affords – should be further explored. This study provides initial evidence that a wiki with discussion seems to support problem-based activity best.

With regard to the methodology, the study adapted Hmelo-Silver and Chernobilsky's (2004) coding scheme initially used to study computer-supported collaborative learning during problem-based activity. The refined coding scheme seemed to work well in this study and could easily be adapted in future work, as recommended by Rourke and Anderson (2004) and deWever et al. (2006). Also, the study demonstrated that using a visual technique together with 'code-and-count' content analysis can help researchers understand the complex interactions that take place during computer-mediated and computer-supported collaborative learning. The technique was inspired by Hmelo-Silver et al. (2009). An extensive discussion of our experiences with using this technique, including benefits and difficulties, appears elsewhere (Ioannou & Stylianou-Georgiou, 2010). It is important to continue to utilize and critically evaluate such techniques that promise to support our understanding of computer-mediated and computer-supported collaborative learning.

With regard to the research design, this study is unique in that it uses a counterbalanced, within-subject design to contrast same group collaboration in wikis and threaded discussion. Studies conducted in the areas of computer-mediated communication and computer-supported collaborative learning are rarely experimental in their research design. Also, existing experimental studies comparing wikis and threaded discussion use different groups of learners in the experimental treatments, i.e., receiving either wiki or forum (e.g., Ioannou, 2011; Vasquez & Potter, 2013; Wicks et al., 2013). We examined all groups of learners in both technologies and in the same context (collaboration on case problems). This design enables a cause and effect relationship that can be attributed to the technology, such as that, threaded discussion 'caused' more talk, though similar content, and wiki 'caused' more contributions to the group artifact. Nevertheless, the study used a sample of convenience, and thus findings should only be generalized to learners coming from a similar population and setting (i.e., graduate students in asynchronous courses working collaboratively on a problem-based activity).

Closing, there are a couple of different directions future research could take. The present investigation lacks a theoretical framework to explain and predict how tools (wikis and forums) might affect the collaborative processes by eliciting and supporting various types of interactions. Examining within-group differences in learners' interactions in wikis and forums is informative for researchers and practitioners; nonetheless, echoing Lund and Rasmussen (2008), there is a need to further theorize the relationship between tasks, tools and collaborators in collaborative learning settings, particularly using wiki technology. Thus, future research could focus on presenting a theoretical account of how wikis and forums affect the collaborative process. Alternatively, future work can engage in some reverse engineering by first, identifying the types of interactions that increase the quality of group artifacts (i.e., essays) in collaborative problem-based activity, then proceed to investigate which tools (wikis vs. forums) are more likely to elicit and support the desired interactions.

## 5. Conclusion

Wikis and forums made their way into online learning more than a decade ago and have been widely used ever since. Nonetheless, there is a dearth of research discussing their effectiveness and limitations for virtual collaboration and learning, and experimental investigations and systematic analysis of students' interactions using both technologies are rare. This experimental investigation contributes to our understanding of how learners use a wiki with discussion (i.e., an enhanced wiki) vs. a forum with attached MS Word documents, in the context of online collaboration on case problems. In sum, the results favor the use of a wiki (with discussion) for this type of activity.

This important finding (and others) should be of interest to instructors who use wikis and threaded discussion tools in their online courses aiming to support collaborative learning. Such findings might help instructors decide to use a wiki, instead of a discussion board, or some combination of both tools, to support collaboration on case problems or other problem-based activities when a group artifact will have to be delivered. At the same time, this study calls for more (experimental) comparisons and contrasts between technologies in the context of particular instructional activities and pedagogies, providing practical implications for online learners and instructors.

## Appendix A

**Table A1**
Guidelines for the analysis of the case problem.

| |
|---|
| Step 1: Defining the problem<br>Try to understand the true nature of the problem. You might want to consider several aspects of the problem. The suggested problem should be supported using information in the case. How you define the problem will guide the development of your consensus plan.<br>Step 2: Identifying facts, stakeholders, and maybe unanswered questions<br>Facts: The "what do we know about the problem" aspects of the case.<br>Stakeholders: Who is involved and what are their perspectives/positions.<br>Unanswered questions: If you had the opportunity to gather more data, what knowledge would you seek to acquire in order to understand the problem?<br>Step 3: Offering interpretation and possible solutions<br>Use your theoretical, pedagogical (application of theory), and professional knowledge to make connections between the problem and possible solutions. Your efforts here should take the form of hypothesis and ideas for solutions grounded in theory. Use implications of the theory we learned in this course to inform your solutions.<br>Step 4: Your consensus plan<br>Produce a plan suggesting a solution to the problem (e.g., "What can the teacher do to help Joe (Case A) to provide the best learning environment for all (Case B)?"). Put your decisions from steps 1–3 in a well written, 2–3 page (single spaced) statement. |

**Table A2**
Discourse categories coding scheme with definitions and examples.

| | Sub-category | Definition | Examples (data from the present study) |
|---|---|---|---|
| 1. Complexity | Telling | This contribution corresponds to a discussion of facts, concepts, and theories with little or no clear connection to the case and earlier ideas contributed to the discussion. | According to Ormrod, "cognitivists have suggested that people are more apt to apply what they've learned if their present context encourages retrieval of potentially useful prior knowledge ..." (Page 426). |
| | Elaborated telling | This contribution corresponds to a discussion of facts, concepts, and theories in relation to earlier ideas contributed to the discussion and with clear connection to the case. | As we discussed, Joe seems to have very low self-efficacy. He has not had many successes, so he does not see himself as a capable learner. When Sherry asks him, "Do you think you can do better?" he replies, "No, it's the best I can do". Thus, low self-efficacy seems to be a product of his experience. According to Ormrod, I would say that he seems to be suffering from learned helplessness; the "I-can't-do-it-even-if-I-try" attitude "results from a sense of lack of control over achievements and circumstances" (Ormrod, p. 517). |
| | Transforming | This contribution corresponds to a *critical* discussion of facts, concepts, and theories in relation to earlier ideas contributed to the discussion and with clear connection to the case; this discussion reflects argumentation and reasoning, beyond simple elaboration. | Although behavioral strategies that provide students with extrinsic rewards can be effective for changing student behavior in the short term, it is important for Karen to remember that over-reliance on extrinsic reinforcement may reduce intrinsic motivation to learn. It is best for Karen to rely as much as possible on social reinforcers, such as smiles, attention for positive behavior, praise, or even just thanking a student for doing something positive in the classroom (Ormrod, p. 56). This will be more likely to encourage a student's sense of efficacy and feelings of mastery. "For many students, the true reinforcers for learning are probably the internal reinforcers–the feelings of success, competence, mastery, and pride–that their accomplishments bring" (Ormrod, p. 57). It is important for Karen to find ways for her low-performing students to feel successful, to catch them doing well, and to reinforce them for it. Rather than viewing these students as problematic because of their weaknesses, Karen needs to identify their strengths and use those strengths to help them improve academically and socially in the classroom. |
| 2. Collaboration | New ideas | Learner presents an idea or opinion that is new in the context of the discussion. Includes ideas about defining the problem and identifying a solution. | The case stated that Sherry has been praising Joe's right answers and ignoring the incorrect ones. I think this may be doing a disservice to Joe. Sherry needs to set reasonably high expectations for Joe. She needs to be honest with him about his ability vs. work and not accept anything less than what he is able to do. This may mean starting with a smaller assignment that Joe completes to the best of his ability (so as |

**Table A2** *(continued)*

| | Sub-category | Definition | Examples (data from the present study) |
|---|---|---|---|
| | | | not to overwhelm). Sherry needs to be consistent with regard to her expectations for Joe. |
| | Modification | Learner partially agrees with a presented idea or opinion, but makes a modification to it. | I agree with you, Jeri. But, I would argue that the reading groups don't need to be totally homogeneous, but that the disparities between students should not be extreme. Students' personalities may also need to be taken into consideration! |
| | Elaboration/ expansion | Learner presents statements, clues, or comments that further refine or expand an earlier idea/opinion; this contribution does not include a critical discussion of concepts and theory to make this complex. | To add to the idea about constructing student knowledge from hands-on experiences …for example, Karen could create a class newspaper and allow students to create articles, research information, and conduct interviews for the paper. This activity would develop more than just their language art skills and would further emphasize the development of the "community of learners". |
| | Agreement/ consensus | Learner presents statements of agreement between and among group members; emphasizes agreement or consensus rather than simply "I agree and here is what I am thinking" | I agree, if Karen can change her approach to teaching, she may be able to raise the reading levels of the students with a lower ability. |
| | Disagreement | Learner presents statements of disagreement between and among group members. | On that note, I'm not sure that you can assume that the "three levels of caring" about the task are directly related to the ability level groupings. I have seen high level students who are ambivalent about classroom activities. |
| | Syntheses/ summaries | Learner presents summary previous ideas; this contribution does not include a critical discussion to make this statement complex. | Based on our discussion so far we are all in agreement with the following 3 issues at least. a) Karen has classroom management technique issues. b) situating the students in some sort of group learning; or peer-groups would help create a learner-centered environment. c) Karen needs other methods to assist the lower level group while challenging the upper level group in terms of motivation. |
| | Acknowledgment | Acknowledgment of a contribution. | Good point about the need to determine in what ways their students are motivated. |
| | Explanatory/ elaborative questions | Asking for clarification or justification of some idea or opinion. | Are there other methods to gain that control without threats, negativity etc? |
| | Meta and prompts | Questions, comments, or suggestions that prompt further discussion; these statements are idea-oriented, rather than task-oriented. | I agree that better readers are more motivated, but are they happy in this classroom learning environment? Are they challenged? |
| | Justification/ clarification | Elaboration, justification, clarification as a result of an elaborative question. | Yes, I think it is a good way to incorporate self regulation, and another good way to think of setting up the modeling pairings. |
| 3. Monitoring & planning | Monitoring and planning | Includes self-monitoring and group-monitoring utterances such as: "I have made a summary of …"or "I am going to start reading …" or "We need to summarize…" or "Let's start working on …" Also, includes decisions about how to move forward with the task. | Let's define the problem and go from there. If we work backwards and state our goal, we could probably come up with an action plan. I will add in some references I found in this week's readings that I think will work in several areas. I will be working on the plan this afternoon and attach my work by this evening. |
| 4. Other content | Tool-related talk | Questions, answers, comments, and clarifications related to the technology. | Can we add some color to new additions so that we can easily review them? |
| | Process-related talk | Questions, answers, comments, and clarifications related to the task or process (other than technology-related). | I need help guys in the citing of information. We used several sources and didn't ever directly quote a source. |
| | Personal and social talk | Talk among group members that do not add directly to the task. | Are you guys ready for Mike's final on Sun? |

**Table A3**
Construction categories coding scheme with definitions.

| Category | Definition |
|---|---|
| Expansion | Learner contributes to the group document by adding new text, which can be thoughts resulting from the groups' discussion or new thoughts of the learner not previously stated. |
| Deletion | Learner deletes an idea, opinion, or theory (or part of it) from |

*(continued on next page)*

**Table A3** *(continued)*

| Category | Definition |
|---|---|
| | the consensus plan (including deletion of one's own contribution). Deletion also includes extensive revision to the extent that one completely changes the meaning of some previous contribution. |
| Content-editing | Learner edits the content of a contribution. This includes adding sentences and references in the existing text without changing the meaning of the text. |
| Formatting & spelling | Learner works on punctuation, spellings, grammar, wording, creating titles/subtitles, or adding fonts and styles. |

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# Online instruction about integration of science and mathematics with middle-grades teachers: Four years in and aiming for sustainability

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ABSTRACT

The purpose of this article is to illustrate the model used to develop an online graduate program called iSMART (Integration of Science and Mathematics and Reflective Teaching) and discuss the changes made in the program over the past 4 years. Starting in 2009 as its preparation year, iSMART is a unique project aimed to provide an online master's program for middle-grade science and mathematics teachers in Texas and is currently working with its 4th cohort of teachers. The authors identify the necessary infrastructure and provide examples for others to consider as they take on similar challenges in developing sustainable online programs with practicing science and mathematics teachers.

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## 1. Introduction

Online courses and programs have emerged as widespread venues of delivering instruction for institutions of higher education (Allen & Seaman, 2013), and are beginning to emerge in teacher professional development (e.g., Dash, deKramer, O'Dwyer, Masters, & Russell, 2012; Groth & Burgess, 2009; Koc, Peker, & Osmanoglu, 2009; Silverman & Clay, 2010). Furthermore, international and national organizations in science and mathematics education such as the *International Council of Associations for Science Education*, *National Science Teachers Association*, and the *National Council for Teachers of Mathematics* advocate the integration of science and mathematics. Despite such heavy advocacy, there are a variety of definitions of what science–mathematics integration actually means (Hurley, 2001; Lederman & Niess, 1997).

Consistent with these trends, in 2009, the authors and their colleagues[1] were charged with the task of designing and implementing a 2-year online master's program for middle-grade science and mathematics teachers. This uniquely designed program, Integration of Science and Mathematics and Reflective Teaching (iSMART), focused on the integration of science and mathematics as a means to further develop teachers' content and teaching knowledge as well as support the development of teacher leadership and technology skills.[2] The social constructivist theoretical framework of the program and the design-based research behind the development decisions were discussed in earlier publications (Lee, Chauvot, Plankis, Vowell, & Culpepper, 2011; Lee, Chauvot, Vowell, Culpepper, & Plankis, 2013). The first cohort of 25 science and mathematics teachers began the 2-year program in fall 2010; subsequent cohorts of 22–27 teachers have been enrolled each year. To date, 66 (of 69) teachers have graduated from the program and 26 more teachers are currently enrolled in the program. All of the participating teachers were/are teaching full time while enrolled in the program, and had been teaching at least 3 years when they started in the program.

The purpose of this article is to illustrate the model used to develop the program and discuss the changes made in the program over the past 4 years. Importantly, we identify the necessary infrastructure for others to consider as they take on similar challenges in developing sustainable online programs with practicing science and mathematics teachers. This account is generated by reviewing over fifteen reports submitted to the funding agency regarding progress toward specified outcomes as well as multiple email correspondences and interviews with the director of the program. Whereas the director of this program is the first author, the second author conducted the interviews and prompted the email correspondences.

## 2. Aiming for sustainability: challenges and revisions

In developing and evaluating the iSMART model, we have used a design-based research methodology. This approach is in line with our theoretical framework of situated cognition (Brown, Collins, & Duguid, 1989; Cognition & Technology Group at Vanderbilt, 1993; Lave, 1988; Lave & Wenger, 1991).

### 2.1. Design-based research

Design-based research is known for incorporating both empirical educational research and theory-driven design of learning environments in

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[2] The opinions expressed here are those of the author and do not necessarily reflect the views of the Greater Texas Foundation.

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order to move beyond the simple sequencing of the design and evaluation of a particular intervention (The Design-Based Research Collective, 2003). Design-based researchers promote research that takes place in the real-world or authentic settings. When effectively employed, the research results inform practice.

Such a framework has proved highly valuable in the evolution of the integrated and complex aspects of the iSMART program. With the emphasis on research embedded in authentic settings, the iSMART faculty have consistently focused on understanding how iSMART teachers define two key aspects of the program: (1) student-centered instruction in middle-school science and mathematics, and (2) the integration of the two subject matters. Also, as teacher educators, iSMART instructors are investigating how this kind of teacher education can be translated and delivered in an online learning environment. Additionally, the iSMART instructors and designers are looking for ways to scale this to a larger audience in a sustainable way. As an inquiry paradigm, the design-based research methodology can "incorporate various methodologies that can reveal the connections between the implemented practice and any theory building that is contextualized within the practice" (Lee et al., 2011. p.192).

In this project, we used the design-based research framework proposed by Reeves (2006). The following section illustrates the four iterative phases of Reeves' model (Amiel & Reeves, 2008; Reeves, 2006) and how the phases were used in the design and implementation of the iSMART project.

#### *2.1.1. Phase 1: analysis of practical problems by researchers and practitioners in collaboration*

- The review of literature pointed to the need for integration among disciplines to better serve the students (Dewey, 1933) as well as provide instruction in the authentic contexts (Ronis, 2007; Roth, 1993).
- The teacher educators and instructors of the iSMART program had previous experiences teaching in middle-school science and mathematics. As with the prevailing literature, these real-world practitioner experiences and perspectives also supported the need for integrated instruction and hands-on learning experiences for the teachers.
- Based on the above issues and findings, a possible solution was identified. More specifically, an idea of providing integrated instruction in science and mathematics for middle-school teachers throughout the state of Texas received funding from a state foundation focused on educational issues. With the funding in place, an online platform was selected in order to reach these middle-school teachers in various locations across the state.
- As part of this process, the following research question was generated: how can one design and implement an online program for middle school mathematics and science teachers in Texas that provides highly integrated instruction situated in authentic learning environments?

#### *2.1.2. Phase 2: development of solutions informed by existing design principles and technological innovations*

- Based on the analysis of the problem identified by literature reviews and extensive experiences as practitioners, a 2-year master's program for middle-school science and mathematics teachers was designed and delivered entirely online.
- The current teacher educators in the two subject areas as well as an instructional technology faculty member have collaborated in the design and the development of the program. The end result was that the math education and science education courses were offered separately but in an integrated way.
- An important aspect of the program was its mandatory synchronous class meetings. That particular decision was based on the program's theoretical framework employing situated cognition which included the use of hands-on lessons.

#### *2.1.3. Phase 3: iterative cycles of testing and refinement of solutions in practice*

- The implementation of the program and subsequent 4 years of testing and refinement of solutions in practice are illustrated in detail in the following section of this paper.

#### *2.1.4. Phase 4: reflection to produce "design principles" and enhance solution implementation*

- The members of the iSMART project team have held regular meetings for the last 4 years in which the weekly reports and student issues were discussed. The ideas and suggestions from these meetings were then implemented in the following classes.
- The cohort system of the iSMART facilitated the collective reflection process among its members as well as between those of the different cohorts.

The two most unique, and, therefore, challenging aspects in this project were to figure out how to deliver the program completely online and then to decide the content of courses that needed to focus on science–mathematics integration at the middle grades. Historically, science and mathematics teacher educators model best practices in face-to-face university classrooms and in professional development sessions as a way to teach about learner-centered instruction with children. Theoretically, a model for how to teach teachers in an online environment about face-to-face learner-centered instruction was needed; we feel that we have developed such a model. Pragmatically, it was necessary to identify/train instructors who could deliver content in an online environment in ways that would still model best practices of face-to-face instruction with children and produce the desired outcomes of improved content knowledge and improved instructional practices of the teachers in the program.

The second main challenge was to design a program that focused on science–mathematics integration, a construct that is loosely defined in the literature. Over the 4 years, we have identified different kinds of enactments of integration that grew from our initial interpretations of science–mathematics integration and our attempts to put our interpretations into practice. In hindsight, we have realized that these enactments of such integration are a testament to what one might expect in developing programs that require genuine collaboration across two or more disciplines. Success is also dependent on a clear and viable working model that addresses online instruction of teachers in a master's degree program.

### *2.2. Program coursework and activities*

The current degree plan and overview of the program activities are illustrated in Fig. 1. The illustration suggests a list and sequencing of discrete courses and learning experiences. To the contrary, the central themes of integration, learner-centered instruction, equity, technology, and reflective practice are threaded across all of the iSMART courses. Whereas Cohorts 3 and 4 followed the sequence of coursework and activities reflected in Fig. 1, Cohorts 1 and 2 experienced several variations from the original program design. These variations, the reasons for the changes, and anticipated upcoming changes will be shared in a subsequent section of this paper.

The intent of the face-to-face orientation that takes place during the summer before coursework begins is to initiate the development of relationships between teachers within the cohort and the faculty members who will be the instructors in the upcoming years. Activities during this orientation include team-building activities. The orientation also provides workshops on how to use the technology that is required during the synchronous instruction of the upcoming semesters (i.e., Wimba Live Classroom or Blackboard Collaborate).

The first semester of the program is a deliberate focus on instruction and pedagogy in science and mathematics classrooms. The second semester, in contrast, steps back to examine broader issues in science

| | |
|---|---|
| **Summer before** | **2½ - day face to face orientation**<br>**Optional online Blackboard Collaborate practice sessions**<br>**Real access to Blackboard Collaborate** |
| **Fall 1** | **Developing Proportional Reasoning**<br>**Teaching Science in Grades 4-8 I** |
| **Spring 1** | **Issues in Mathematics Education**<br>**Curriculum Development in Science Ed.** |
| **Summer 1** | **Capstone Project Seminar**<br>**5-day face-to-face iSMART Summer Conference** |
| **Fall 2** | **Professional Seminar I**<br>**Teaching Science and Mathematics with Technology**<br>**Teaching Science in Grades 4-8 II** |
| **Spring 2** | **Professional Seminar II**<br>**Education in a Multicultural Society** |

**Fig. 1.** iSMART coursework and activities.

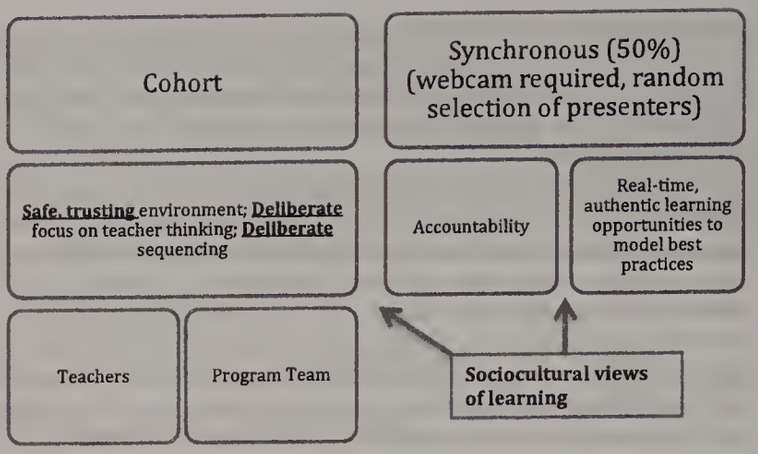
Cohort
Synchronous (50%) (webcam required, random selection of presenters)
Safe, trusting environment; Deliberate focus on teacher thinking; Deliberate sequencing
Accountability
Real-time, authentic learning opportunities to model best practices
Teachers
Program Team
Sociocultural views of learning

**Fig. 2.** iSMART model.

and mathematics education that surround curriculum development. The face-to-face 5-day summer conference between the two academic years is designed to celebrate accomplishments of the first year as well as set the stage for the upcoming second year of coursework. The third semester of coursework returns to a focus on science and mathematics classrooms and how technology can facilitate the development of science and mathematics concepts. The last semester attends to frameworks regarding equity and social justice in K-12 schools in general as well as specifically in science and mathematics classrooms.

### *2.3. A model for online instruction of teachers*

In the initial design and in the ongoing revisions of the program, the developers were pushed to broaden their views of best practices when teaching teachers. As has been reported earlier (Lee et al., 2011, 2013), the two primary instructors of the first implementation year, experienced teacher educators of science education and mathematics education, had taught the same courses in a face-to-face format, but were relatively new to the online teaching experience. The faculty member in science education specifically had no prior experience teaching in an online environment and was concerned about whether or not he could replicate the hands-on experience and live in-class discussions in the online setting. The mathematics teacher educator who is also the first author of this paper had taught a fully online course in 2009 and was more familiar with the format, but reported limited success in the 2009 course as compared to what she was used to in her teaching of face-to-face courses. Both primary instructors were also adamant about aligning their instruction with their respective philosophies of learning. Both strongly believed in the inquiry-based and problem-solving methods of instruction they employed in their face-to-face courses.

Consistent with research about teacher learning and driven by sociocultural views of learning (Vygotsky, 1978, 1986), the iSMART design team decided upon a program model that highlighted the utilization of a cohort model, which led to deliberate instructional choices made in each course in the context of the full program. Among these decisions, was to balance the utilization of both asynchronous and synchronous instructions (see Fig. 2). This initial model has remained relatively intact over the 4 years.

#### *2.3.1. Cohort of teachers, cohort of faculty, assistants and staff*

The use of a cohort model has two meanings for us. First, the teachers go through the 2-year program as a cohort. Throughout the 2 years, they work through a specific sequence of courses as a whole group. Second, we consider the program team as a cohort. The program team consists of faculty, graduate assistants, administrators, and staff, all contributing different kinds and levels of expertise to the program. Initially, the faculty and graduate assistants met weekly, and administrators and staff contributed as needed. During the third implementation year, the group found it sufficient to meet biweekly. We expect that the team will meet every 3 weeks or so during the fourth implementation year. This change to fewer required meetings speaks to the noted stability of the program in that several procedures involving schedule, review of applications, admissions, and enrollment into courses have become routinized.

Cohort models are reported in the research literature in a variety of contexts as useful for capitalizing on the power of interpersonal relationships to promote learning (Govender & Dhunpath, 2011; McPhail, Robinson, & Scott, 2008; Nimer, 2009; Rausch & Crawford, 2012; Ward & Overall, 2011). In accordance with the literature, the utilization of cohorts in our model has provided many benefits. Each cohort of teachers created collaborative and trusting relationships with one another and with faculty, since the faculty teach multiple courses to the same cohort over the 2 years. As a result, the program faculty are able to focus on group and individual teacher thinking and to deliberately sequence (and revise) course and program activities accordingly. Essentially, course goals are able to be linked closely with program goals, providing coherency. Consequently, learning theories are applied to the whole program rather than just a single course. The cohort model allowed for deliberate course and program revisions based on the program team's interpretations of progress toward desired program outcomes.

Furthermore, the cohort of faculty members have benefited from the collegial support as they have developed and refined their pedagogical practices in online environments. Program team meetings sometimes became "just-in-time" professional development sessions for faculty as they shared strengths and weaknesses of instructional strategies they employed in their online classes. This just-in-time support is an important finding in that although the program team had engaged in preliminary training about online instruction, *prior* to the first implementation year, the more meaningful professional development occurred in these impromptu sessions of sharing instructional ideas *during* the first and subsequent implementation years.

For example, in order to foster skills in cohort teachers for effective online collaboration, the program team reviewed archived synchronous small and whole group sessions from Year 1 coursework in terms of the kinds of interactions that occurred. The team also examined asynchronous venues, such as discussion boards, and conducted one-on-one interviews with Cohort 1 teachers at the beginning of the spring 2011 semester. The team also looked for evidence of knowledge construction in either the subject matter content area or knowledge construction of pedagogy within these synchronous and asynchronous environments.

Our review of interactions within synchronous instruction revealed a concern that the ideas of students who were only interacting via the chat box were sometimes missed and not shared. This finding alerted

instructors toward more careful monitoring of the chat box during instruction. In addition, it prompted instructors to encourage students to share their thinking via the "talk" button.

Another pattern was noted in regards to specific students who seemed to choose to *only* interact via the chat box, and in a minimal way. The instructors addressed this by (1) speaking one-on-one to the student, (2) requiring that all students use their webcams, and (3) by using random selection when calling on students during any of the synchronous sessions. Finally, the analysis of first semester small group interactions led to deliberate reassignment of small groups for the second semester in order to facilitate more collaboration and productive interactions. Overall, however, the team has been extremely pleased with level of collaborative and reflective activity that has been evident in the synchronous interactions between the program instructors and the cohort teachers.

The asynchronous venues also showed high levels of collaborative behavior and reflective activity. The instructors, however, reported that the discussion boards, at least in the first semester, were too cumbersome. They were uncertain of the instructional value. Consequently, each instructor modified his or her use of discussion boards in the second semester. As part of the program team's on-going research agenda, it has been important to systematically document knowledge construction in online environments.

*2.3.2. A balance of synchronous and asynchronous online instruction*

Synchronous instruction is an important component of the program model because it is consistent with sociocultural theories of learning. Synchronous instruction allows for real-time, in the moment opportunities to develop and broaden ideas. We feel that it also provides a higher level of accountability in that meeting face-to-face via webcam on a regular basis facilitates continuous interactions with course materials and one another. Real-time instruction also provided opportunity to replicate what might happen in face-to-face instruction with children. For example, the synchronous instruction time allowed university faculty to model how one might orchestrate a whole class discussion after students have worked on a problem in small groups.

Our initial structure with the first cohort was to schedule both courses the same evening for 3 h, where all 25 teachers and the instructor met via webcam. At the time, we were using Wimba Live Classroom available through Blackboard Vista. We are now using Blackboard Collaborate within Blackboard Learn. Cohort 1 teachers met for 90 min in one class and then 90 min in the other class. The remaining content for each course was delivered asynchronously, with the expectation that teachers would engage with the course content through small-group projects and discussion board activities an additional 90 min per course per week.

In the second year, after the second cohort of teachers started, the initial schedule became problematic due to some instructors teaching in both cohorts. After some deliberation, we then switched to a model where teachers meet synchronously for 3 h on Wednesday evenings using Blackboard Collaborate. In this new model, they attend one class on one Wednesday, and meet with the other class the following Wednesday. In addition, there is an expectation that students will spend 3 h a week engaged in asynchronous activities for each course. This now established routine of always offering program courses on Wednesday evenings has had broad implications in terms of establishing faculty work-load schedules which has reduced schedule conflicts across the board.

Overall, the teachers of the program report that they prefer having the synchronous sessions, even though this means less flexibility in the schedule, as compared to online programs that primarily meet asynchronously. For that reason, we have had to be careful about describing our program in recruitment materials. Applicants to online programs sometimes assume that the coursework will be available 24 h a day and that there is no specific weekly time-frame for course attendance. We have found that making our expectations explicit on our website (e.g., Teachers must be available at a computer with a webcam for synchronous instruction Wednesdays, 5:30–8:30 pm) and then going over these expectations during our phone interviews and email interactions with the applicants has been significant in supporting the students of our program. Suffice to say, given the cohort teachers' full-time work schedules, it is vital to be open and frank about program requirements and expectations with all participants as well as budding applicants and those recommending the program to others. As is often typical with novel higher education programs, ours is sustained via word-of-mouth advocacy. To help in such efforts, we strongly recommend keeping the program website and marketing materials simple and straightforward. Accessible online calendars of events also help participants learn about program updates as well as check their progress. Clarity will elevate the future success of the entire program since people will not apply if they lack the necessary time, resources, skills, and willpower.

Even though we have designed the program in this fashion, there remain other complexities that must be addressed. For example, the department that houses the M.Ed. underwent department, college, and university-approved changes that went into effect for the second cohort of teachers in our program. These changes "interrupted" the originally decided upon sequence of courses as well as altered the model described in Fig. 2. It is important to note that in a system of higher education it is not uncommon for such complexities to arise. The issue for us was how to adapt to the contextual changes that were occurring while sustaining the integrity of the program.

Program changes also occurred in response to feedback from the teachers of the program. Fig. 3 summarizes significant changes that were prompted either within or outside the program. As one reads from left to right, significant changes are bold and underlined.

One significant change that began with cohort 2 was that two new department-required courses, both professional seminars, were to be delivered entirely asynchronously. They are required of all M.Ed. students of the department, not just students in our program. The professional seminars were designed as three, 5-week mini-seminars in the fall semester, and three additional 5-week mini-seminars in the spring, where each mini-seminar was taught by a different instructor. Students were to be alphabetically assigned to one of the three mini-seminars and then rotated to the next mini-seminar every 5 weeks; consequently, our cohort members of 22 teachers were distributed across multiple sections of the course. In other words, although our teachers would all take the professional seminar course during the same semester, they may not be enrolled as a unit of one cohort in the same section. Finally, to increase the diversity of the content, the mini-seminars are taught by six faculty members who were not a part of the original program team.

What we have learned from studying this change with Cohort 2 is that although some Cohort 2 teachers had a difficult time adapting to the entirely asynchronous professional seminars, the change has been highly advantageous because the teachers in our program are now interacting with additional M.Ed. students of the department outside of their discipline, which has enhanced their learning experiences. Also, since they are still together, as a cohort, in their science or mathematics education courses each semester, they continue to support one another. In other words, the support system and collaborative relationships that were initially established in the first year provided a supportive structure as they encountered an entirely asynchronous learning environment for the first time in the second year. We feel strongly that before our future cohorts enroll in the entirely asynchronous courses, we will want them to have had at least one semester of two courses together to develop collaborative relationships with one another to establish this support system.

The strength of our model in Fig. 2, that emphasizes the program team, a cohort of faculty, graduate assistants, staff and administrators, is that we have been able to collaboratively address complexities as they arise. This framework has made transitions to new policies and procedures run smoothly.

| Cohort 1<br>36 hours with a Master's Thesis | | Cohort 2<br>30 hours with a Capstone Project | Cohorts 3 & 4<br>30 hours with a Capstone Project |
|---|---|---|---|
| Overview<br>• Science and Mathematics Education (21 hours)<br>• Required College Core (9 hours)<br>• Master's Thesis (6 hours) | | Overview<br>• Science and Mathematics Education (21 hours)<br>• Required ***Departmental*** Core (9 hours) – ***ASYNCHRONOUS DELIVERY***<br>• ***Capstone Project*** | |
| Fall 1 | Developing Proportional Reasoning<br>Teaching Science in Gr 4-8 | SAME | |
| Spring 1 | Issues in Mathematics Education<br>Curriculum Development in Science Ed | SAME | |
| Summer | Teacher as Researcher<br>Research for Educational Leaders | ***Capstone Seminar*** | |
| Fall 2 | Teaching Science and Math with Technology<br>Education in a Multicultural Society<br>Master's Thesis | ***CUIN Professional Seminar I - Asynch***<br>Teaching Science & Math with Technology | CUIN Professional Seminar I<br>Teaching Science & Math with Technology<br>***Teaching Science in Gr 4-8 II*** |
| Spring 2 | Teaching K-12 Environmental Education<br>Principles of Human Learning<br>Master's Thesis | ***CUIN Professional Seminar II - Asynch***<br>***Teaching Science in Gr 4-8 II***<br>Education in a Multicultural Society | CUIN Professional Seminar II<br>Education in a Multicultural Society |
| Significant Changes/ Explanation | Master's Thesis became Capstone Project during the second year/Cohort 1 served as a pilot for upcoming departmental level changes toward a required Capstone Project for M.Ed students. | Department transitioned to a 30 hour M.Ed with a Capstone Project and required Professional Seminars<br><br>Environmental Ed course was replaced with a continuation of Teaching Science course/ Outcomes indicated that more was needed regarding inquiry-based instruction | Moved second Teaching Science course to Fall 2/Spring semester conflicted with high-stakes testing in schools, making it difficult for teachers to be enrolled 9 hours and finalize Capstone Project. |

**Fig. 3.** Summary of iSMART program changes.

### 2.4. Enactments of science–math integration

The second main challenge we have encountered was to design a program that focused on science–mathematics integration, a construct that is loosely defined in the literature. This was particularly a challenge because the existing master's degree programs in the department included an emphasis on mathematics education *or* science education; it did not have a degree program that emphasized *integration* of the two content areas. As we moved forward, each degree program had specific program area requirements that needed to be renegotiated, in the name of integration.

Our initial interpretations of science–mathematics integration are shared in (Lee et al., 2013) and (Lee et al., 2011). Briefly, we primarily worked from the Berlin and White (1994) model, which focuses on six aspects of integration: (1) ways of learning, (2) ways of knowing, (3) process and thinking skills, (4) content knowledge, (5) attitudes and perceptions, and (6) teaching strategies. This model was useful for us because it allowed us to consider integration from different perspectives as we re-designed our courses. For example, in the first semester of the program, "the cookie lesson" (Plankis, Vowell, & Ramsey, 2011) is used in the middle-grade science method course to focus on ways of learning and knowing as well as process and thinking skills in both science and mathematics classrooms while simultaneously addressing the content of proportional reasoning. Such an activity pushes students to reflect on the content that they are learning in "*Developing Proportional Reasoning*" which is the second course the teachers are taking during that same semester. Similarly, a lesson on oil spills (http://www.learner.org/workshops/algebra/workshop7/lessonplan1.html) in the proportional reasoning course highlights direct variation and learner-centered teaching strategies. It also provides a context for teaching about environmental education in the middle-grade science method course.

In the second semester of the program the teachers are enrolled in two seminar courses. This approach is in contrast to the two method courses of the first semester. One seminar course focuses on curriculum development in science education, whereas the other addresses curriculum reform in mathematics education, teacher change, teacher leadership, and reflective practice. Both courses address the role of politics and policy in education reform and issues of social justice and equity. These areas are of interest to both science and mathematics education but are not necessarily addressed in the science–mathematics integration models such as proposed by Berlin and White (1994). In other words, if we are to address science–mathematics integration in K-12 schools, we need to also address what science–mathematics-teacher-education integration might look like in institutions of higher education.

The program team had broader interpretations of what science–mathematics integration might be as compared to the first cohort of teachers (Lee et al., 2011). These differences in interpretation between program participants and program staff continued during the next two cohorts. Essentially the teachers' initial definitions of integration emphasized the integration in terms of mathematics as a tool to be used in scientific investigations and instances where the subject matter naturally overlapped. The program team members' included these definitions but also added the additional aspects as described in Berlin and White (1994). They now have begun to recognize additional points of integration such as those described in the seminar courses of the second semester.

As another example, learner-centered instruction is a construct that is desired across both science and mathematics education. In fact, science and mathematics teacher educators alike strive to model best practices from this perspective. What became evident from within course assessment of student products during the second year of implementation with the first cohort was how further experiences that focused on learner-centered instruction were needed. This insight about learner-centered practices led to programmatic revisions of course offerings within the program as well as changes to specific assignments within courses. This program revision is significant to our enactment of integration as we consider learner-centered as one of the primary aspects of science–mathematics integration. In the end, we used this construct as a conduit for facilitating growth in science and mathematics

knowledge as well as a model for best practices in teaching science and mathematics.

*2.4.1. Subject area content knowledge*

The first step to learning the integration of science and mathematics is to have a sufficient understanding of each subject area contents. The iSMART team used proportional reasoning, learner-centered instruction, and scientific inquiry as conduits for facilitating growth in content knowledge that is specific to the teacher and determined by the teacher's given teaching assignment.

For Cohort 1, the iSMART instructors focused on proportional reasoning and the associated mathematical constructs (e.g., covariance, unitizing, and additive and multiplicative reasoning), including children's thinking in proportional reasoning contexts. The faculty witnessed increased recognition of where proportional reasoning is utilized within mathematics and science TEKS (Texas Essential Knowledge and Skills). The indications of this improvement were shown in participant responses on the initial surveys as well as on the proportional reasoning midterm and final exams. It was also displayed within iSMART teacher analysis of their interviews with children and their small group discussions about articles that they selected. Because proportional reasoning is embedded across multiple middle-school science and mathematics content areas such as measurement, probability and statistics, algebra, density, solar system, mixtures, force, and energy, there were multiple ways in participant growth demonstrated.

Furthermore, Cohort 1 teachers reported growth in content knowledge in areas unrelated to proportional reasoning. This occurred within coursework that encouraged teachers to develop and reflect upon lessons/activities that were relevant to their classroom at the given time. Because teachers are teaching different grade levels and different contents, it was not uncommon to have a teacher report growth in content areas that were not directly addressed in iSMART coursework. The middle-school science method course used different science contents to teach about learner-centered instruction, the nature of science, and scientific inquiry. Again, by focusing on big ideas such as learner-centered instruction, nature of science and scientific inquiry in multiple content areas, iSMART teachers have had opportunities to develop subject matter knowledge across many domains. Seven Cohort 1 teachers were observed or submitted video segments of an integrated lesson in Spring 2011. The rest of Cohort 1 teachers submitted video files of an integrated lesson by Spring 2012.

For Cohort 2, the course assignments and midterm and final exam scores indicated improvements in proportional reasoning knowledge throughout 2010–2012. As is consistent with the literature about proportional reasoning, many of the teachers viewed proportional reasoning as setting up a proportion and cross-multiplying to yield a solution. These perspectives broadened significantly to include careful attention to ideas such as unitizing, covariance, qualitative reasoning, absolute and relative reasoning, and the role of providing examples and non-examples to develop proportional reasoning.

The iSMART instructional team developed assignments that focused on developing teachers' understandings of science and math integration. They included reading and creating study guides of literature about integration, conducting and analyzing interviews with teachers, administrators, and students on their respective campuses, and analyzing the TEKS and making recommendations to policymakers regarding integration in middle-school Texas classrooms. The iSMART participants of both cohorts were required to provide a lesson cycle along with video recording of the lesson by the end of the semester.

*2.5. Fostering teacher leadership skills*

From program inception, the iSMART team looked for ways to build a program that is not only sustainable but also scalable. In particular for the issue of scalability, it was important to foster leadership skills in the participating iSMART teachers. Two design decisions were made toward this goal. First, summer conferences were used as a platform for the cohorts of teachers to meet in person and generate recommendations to policy makers and funding agencies. Some of their recommendations were as follows:

- Fund a small school district to implement lessons (start small to be able to grow big; such an approach could provide data that will motivate change).
- Pilot schools throughout the state, using teachers within iSMART or teachers who are proficient with integrating mathematics and science, to collect data that compares integration versus traditional teaching.
- Re-write TEKS to work on aligning math and science standards (generating a scope and sequence) across grades so that compatible topics/skills are more easily integrated.

Second, the iSMART team considers teacher leadership as a necessary component in scaling such types of programs. We think one aspect of teacher leadership involves having the knowledge and skill sets to secure external funding for their school or classroom and supported iSMART teachers as they wrote various grants to various sources. Another aspect of teacher leadership includes the capacity to systematically evaluate programs or curricula that a school adopts, or is considering adopting. Or alternatively, teacher leaders need to examine specific instructional strategies and any corresponding impact on learning. The iSMART teachers are guided to pursue these issues in their capstone project as shown in some of the topic examples below.

- Using problem solving to teach basic skills in eighth grade mathematics
- A pilot study: The effectiveness of the APEX program in motivating economically disadvantaged and at-risk middle school boys.
- The relationship between STEM curriculum and test scores in middle school science and mathematics
- Minute to win it: Middle school physics
- Will curriculum compacting in middle school science lead to student success in biology in 8th grade?
- Excel'ing conceptually in measurement standards

The above topics about teacher change and teacher perspectives as a way to understand how to design appropriate and effective professional development for science and mathematics teachers demonstrate growth in teachers' understanding about these critical issues. Such displays of growth were highly encouraging to the program designers as well as the funders.

Coursework for Cohort 2 underwent revisions to make teacher leadership a stronger component of iSMART. Specifically, further readings as well as additional synchronous time were added to highlight teacher change and how to support teachers in changing their instructional practices. Many of the Cohort 2 teachers were already in a position of leadership but often lacked the necessary supports within their districts. One intent of the "Study of Practice Project" was to place the teacher leader in a position of reflecting on his or her own changes while using a literature base (i.e., research studies and articles about teaching practices) to provide a rationale for desired changes. This experience was then used as a resource in supporting other teachers' change in practices. Some of the teachers reported utilizing and applying what they had learned from the Study of Practice Project to their work with teachers on their individual campuses.

## 3. Discussion

As we continue to look for better ways to sustain the program, we would like to reiterate the following three points. The first point is the importance of real-time interaction. As we start with the fourth cohort at the time of this writing, the iSMART team is confident that the regular synchronous meetings set the program apart from many other online master's programs and make it possible to stay true to the instructional

team's philosophical values as situated cognitivists. Real-time online meetings provided the necessary structure for a program offered completely in an online delivery format. Along the same lines, we have designed the orientation and summer conferences to serve as platforms to bring the cohorts together, where the previous cohort could share their experiences with the incoming one.

The second point is the benefit of the cohort system, both with the iSMART teachers and the instructional faculty. From the start of the program in 2009, the original faculty team has remained the same with the addition of new instructors. The current team, consisting of three instructors in math and two in science, works as a cohort, designs and develops this innovative curriculum and all other iSMART activities. Each member had an opportunity to revise his or her curriculum with each incoming cohort of iSMART teachers based on the team's collective knowledge gained over the years.

The final point is the issue of scaling up. As presented earlier, in an attempt to foster the extension and reach of the program as well as overall sustainability, iSMART instructors focus on fostering leadership within the iSMART teachers. During the program, the iSMART teachers are asked to bring real-life issues in their schools that impede successful integration of science and math. We are now more acutely cognizant of the need for systemic change, including changes in standardized testing as well as in the curriculum on a larger scale. How can the iSMART program continue to impact a larger audience beyond the funding period? And how can graduates from the program make an impact beyond their classrooms and schools that lead to systemic change? These are the questions the iSMART team strives to answer with the iSMART graduates as they continue on their reflective integrated practices after their successful completion of the program.

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# Externally-facilitated regulation scaffolding and role assignment to develop cognitive presence in asynchronous online discussions

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ABSTRACT

This paper describes a study that looked at the effects of different teaching presence approaches in communities of inquiry, and ways in which student–student online discussions with high levels of cognitive presence can be designed. Specifically, this paper proposes that high-levels of cognitive presence can be facilitated in online courses, based on the community of inquiry model, by building upon existing research in i) self-regulated learning through externally-facilitated regulation scaffolding and ii) computer-supported collaborative learning through role assignment. We conducted a quasi-experimental study in a fully-online course ($N = 82$) using six offerings of the course. After performing a quantitative content analysis of online discussion transcripts, a multilevel linear modeling analysis showed the significant positive effects of both externally-facilitated regulation scaffolding and role assignment on the level of cognitive presence. Specifically, the results showed that externally-facilitated regulation scaffolding had a higher effect on cognitive presence than extrinsically induced motivation through grades. The results showed the effectiveness of role assignment to facilitate a high-level of cognitive presence. More importantly, the results showed a significant effect of the interaction between externally-facilitated regulation scaffolding and role assignment on cognitive presence. The paper concludes with a discussion of practical and theoretical implications.

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## 1. Introduction

Benefits of social interaction are well-documented in educational research. With the development of (educational) technology, especially computer-mediated communication, many benefits of social interaction are demonstrated in online education such as increased sense of community (Dawson, 2008), creative potential (Dawson, Tan, & McWilliam, 2011), critical thinking (Garrison, Anderson, & Archer, 2001), and integration into learning communities (Haythornthwaite, 2002). The community of inquiry model is one of the best studied theoretical frameworks in online education. Aiming to promote the ideals of higher education (Garrison, Anderson, & Archer, 1999; Garrison & Arbaugh, 2007), the model inspired many researchers to conduct studies and produce empirical evidence about the effectiveness of the model (e.g., for development of critical thinking and problem solving skills). Most of the existing studies focused on investigating effects of different instructional strategies to promote desirable learning outcomes – referred to as cognitive presence in the community of inquiry model – through engagement in asynchronous online discussions. However, limited research is available that investigated the effects of different instructional strategies on the knowledge construction of every individual student involved in a community of inquiry. Thus, the question arises about the equitable learning opportunities for all students in a community of inquiry (Rovai, 2007). Likewise, most of the studies emphasized the importance of leadership role of instructors and direct instruction in order to facilitate high-level learning outcomes through asynchronous online discussions (Garrison & Cleveland-Innes, 2005). While instructional involvement is important for an educational experience, research evidence shows that student–student discussions lead to deeper learning than instructor-centered discussions (Schrire, 2006). Cost effectiveness and scalability of classes is another important concern attributed to direct involvement of instructors in online discussions (Anderson & Dron, 2011).

This paper proposes that the consideration of self-regulated learning and computer-supported collaborative learning (CSCL) research can offer important insights in order to address the above concerns related to the community of inquiry model. For the self-regulated learning perspective, it is important to recognize the lack of learners' skills to self-regulate own learning (Bjork, Dunlosky, & Kornell, 2013). In particular, this study investigates the effects of *externally-facilitated regulation scaffolds* that are already shown as effective in Web-based learning (Azevedo, Moos, Greene, Winters, & Cromley, 2008). From the perspective of the CSCL research, the emerging script theory of guidance (Fischer, Kollar, Stegmann, & Wecker, 2013) indicates that student–

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student discussions can be facilitated and high-level of knowledge construction can be achieved through scripting[1] and assigning roles to students (De Wever, Keer, Schellens, & Valcke, 2010; Schellens, Keer, Wever, & Valcke, 2007). To empirically validate this proposition, the paper reports on the results of a study in which the effects of externally-facilitated regulation scaffolding and role assignments were investigated in a fully-online master's level course throughout its six consecutive offerings from 2008 to 2011.

## 2. Background

### 2.1. Community of inquiry model

Being social constructivist in nature, the community of inquiry model is concerned with higher-order learning – an ideal of higher education – through computer-mediated interaction of learners and educators (Garrison & Arbaugh, 2007; Garrison et al., 1999, 2001). According to Garrison et al. (2001, p. 7), a community of inquiry "involves (re)constructing experience and knowledge through the critical analysis of subject matter, questioning, and the challenging of assumptions (Dewey, 1959; Lipman, 2003)." An effective educational experience in such a community is facilitated through the interaction of the three cornerstones of the model: *cognitive presence*, *social presence*, and *teaching presence*. Focused on higher-order thinking rather than an individual learning outcome, cognitive presence is defined as "the extent to which the participants in any particular configuration of a community of inquiry are able to construct meaning through sustained communication (Garrison et al., 1999, p. 89)". Cognitive presence is explained through the model of critical thinking, i.e., practical inquiry model (PIM) (Garrison et al., 1999). Similar to the work of Duffy, Dueber, and Hawley (1998), PIM distinguishes the four phases of cognitive presence (Garrison et al., 2001): i) triggering event — the initiation of a critical inquiry; ii) exploration — a move from the private world of an individual to the shared world of social exploration in critical inquiry; iii) integration — a construction of meaning based on the information shared in the exploration phase; and iv) resolution — a solution to the idea/dilemma through a direct or vicarious action. Indicators of each of the four phases of cognitive presence were identified by Garrison et al. (2001).

Social presence is a necessary antecedent of an effective educational experience in a community of inquiry (Garrison & Arbaugh, 2007; Garrison, Cleveland-Innes, & Fung, 2010). Social presence of learners is established by providing learners with opportunities to develop "the ability to project their personal characteristics into the community of inquiry, thereby presenting themselves as 'real people' (Garrison et al., 1999, p. 4)". By establishing social presence, the participants of a community of inquiry create a safe environment in which they can be engaged in a practical inquiry with the members of the community. For example, Rovai (2002) showed that a strong sense of community increased cognitive learning, while a positive causal relationship between perceived measures of social and cognitive presence was empirically confirmed by Garrison et al. (2010).

### 2.2. Establishing and maintaining cognitive presence in online discussions

Importance of teaching presence for "establishing and sustaining an online learning environment and realizing intended learning outcomes" (Garrison et al., 2010, p. 35) is confirmed in numerous studies (Garrison, 2011; Garrison & Arbaugh, 2007; Garrison & Cleveland-Innes, 2005; McKenzie & Murphy, 2000; Meyer, 2003; Pawan, Paulus, Yalcin, & Chang, 2003; Rovai, 2007). Moreover, Garrison et al. (2010) confirmed a causal relationship from teaching presence to both social and cognitive presence, and thus, reinforced the hypothesis that social presence is a mediating variable between teaching and cognitive presence. Consistent with this, early studies of online discussions observed that the students without explicit guidance would engage in "one-way interaction (serial monologs)" (Pawan et al., 2003, p. 135) and only exchanging commentaries without responses to peers' posts (McKenzie & Murphy, 2000). Cognitive presence in such discussions was reported as low with the great majority of posts remaining in the triggering and exploration phases (Kanuka, 2011; Pawan et al., 2003). Thus, the inquiry process of a community would not lead to the desirable learning outcomes and higher order thinking.

Teaching presence is theorized to consist of three components (Anderson, Rourke, Garrison, & Archer, 2001): instructional design, facilitation, and direct instruction. Arbaugh and Hwang (2006) reported the result of a study that confirmed the validity of this construct and its concomitant components. The positive effect of these three dimensions for reaching higher levels of cognitive presence is reported in numerous studies (Garrison & Cleveland-Innes, 2004, 2005; Pawan et al., 2003; Rovai, 2007; Young, 2006). However, developmental factors can make it difficult for some populations of learners (e.g., undergrads vs. graduate students) to distinguish between facilitation and direct instruction (Garrison et al., 2010). For example, Shea, Sau Li, and Pickett (2006) showed that teaching presence is best described by two factors of teaching presence — instructional design and directed facilitation (a combination of facilitation and direct instruction). Integrating the findings of several studies about facilitation of cognitive presence in online discussions, Garrison and Cleveland-Innes (2005) identified instructional design (create structured and cohesive discussions) and clearly defined roles (leadership of instructors in particular) as critical.

### 2.3. Research questions

Our literature review revealed the following two research gaps, which motivated the formulation of our research questions. First, most of the present studies report frequency distribution of the four phases of cognitive presence for entire groups involved in the studies. Those studies were mainly done through quantitative content analysis by coding online discussion transcripts with the four phases of cognitive presence (Garrison et al., 2001; Pawan et al., 2003; Richardson & Ice, 2010). However, our research did not reveal a study, in which the effects of specific instructional strategies were analyzed for each individual student. Although group learning and problem solving is important and students can have learning benefits through so-called vicarious participation (Sutton, 2001), it is at least equally important for each individual student to be deeply involved in the knowledge construction process and highly active cognitive processing operations (Bjork et al., 2013; Schellens & Valcke, 2005). This is especially important in situations in which students are provided with the benefits of social construction, while working on personalized problems that are assessed individually.

Second, the leadership role of instructors, their high participation in discussions, and in general facilitation and instruction as critical components of teaching presence for engaging students in deep learning and high cognitive presence (Garrison & Arbaugh, 2007; Garrison & Cleveland-Innes, 2005). While effective, such an approach to facilitating discussions might not be scalable (Anderson & Dron, 2011). However, student-led discussions and student–student interactions can offer important education benefits (Johnson, 1981) as illustrated through the following findings (a) effect size of student–student interaction on achievement was found to be higher than those of student–instructor and student–content in a meta-analysis of interaction types in distance education (Bernard et al., 2009); (b) cognitive presence of students in student–student discussion threads was found to be higher than in student–instructor discussion threads (Schrire, 2006); and (c) stronger integration of students in learning communities can increase the level of student retention in classes (Tinto, 1997). Unfortunately, a recent

[1] Collaboration scripts are recognized as the key scaffolding approach in CSCL, whereby a script can be defined as "a more detailed and more explicit didactic contract between the teacher and the group of students regarding to their mode of collaboration (Dillenbourg, 2002, sec. Introduction, para. 3)."

study showed that only 1% of faculty members incorporate these strategies into the design of their courses (Lynch, Kearsley, & Thompson, 2011).

We posit that student–student online discussions with a high level of cognitive presence can be achieved through an effective instructional design, which can compensate for the other two components of teaching presence – facilitation and direct instruction. Such instructional design should promote a high level of cognitive presence of individual members of a community and the community as a whole. This proposition can be considered in terms of interaction types – a well-established construct in distance and online education initially proposed by Moore (1989) and extended by Anderson (2003) – whereby facilitation and direct instruction can be considered student–instructor interaction types. As suggested by Anderson (2003), the advancement of (learning) technologies affords replacing student–instructor interactions with student–content interactions, which is consistent with our claim. To support our claim, we build upon research on self-regulated learning (Winne & Hadwin, 1998) and scaffolding in computer-supported collaborative learning (CSCL) (Kobbe et al., 2007) and investigate the following two research questions.

*2.3.1. RQ1: what is the effect of external motivation and external regulation standards on the development of cognitive presence?*

Models of self-regulated learning deem learners are agents (Bjork et al., 2013). Learners decide which information or learning activity is relevant and induce how it supports their goals. Learners set their goals based on *external* (e.g., course grading policy or task requirements) and *internal* (e.g., knowledge of collaborative learning and intrinsic motivation to learn) *conditions*. The goals are modeled as a set of *standards* for cognition, e.g., extent to which ideas from multiple sources should be integrated. These standards are used for the *evaluation* of the effectiveness of learning through: i) metacognitive control of learning activities they perform while studying, and ii) metacognitive monitoring of their learning by evaluating their learning products against the learning goals in order to inform their decisions about own learning. However, research indicates that many learners are not skilled at self-regulated learning (Bjork et al., 2013). In particular, weaknesses are reflected by the use of inaccurate standards in metacognitive monitoring (e.g., quality of their discussion contributions or time budgeted for collaborative activities) and ineffective tactics they apply while learning (e.g., approaches to seeking, integrating, and sharing information in their inquiry process) (Bjork et al., 2013).

Self-regulation and metacognition are gaining more attention in the research about the community of inquiry model and CSCL (Akyol & Garrison, 2011; Cho & Kim, 2013; Garrison & Akyol, 2013; Shea & Bidjerano, 2010). Shea and Bidjerano (2010) empirically validated associations between key constructs of self-regulated learning (e.g., self-efficacy and effort regulation) with the three components of the community of inquiry model. The emphasis on motivation of Shea and Bidjerano's findings is consistent with several previous studies highlighting the importance of including grading of student participation in online discussions (Conaway, Easton, & Schmidt, 2005; Davies & Graff, 2005; Gilbert & Dabbagh, 2005; Palmer, Holt, & Bray, 2008; Rovai, 2007). However, grading of participation in online discussions is insufficient if only quantitative standards are defined (Palmer et al., 2008) and requires additional support for students to help them regulate their learning in a community of inquiry (Cho & Kim, 2013).

Metacognition in the community of inquiry model is a complex construct that "integrates individual and shared regulation (Garrison & Akyol, 2013, p. 84)." That is, in addition to the weaknesses in self-regulated learning indicated above, shared regulation should also be considered when designing effective participation requirements. Consistent with this, the script theory of guidance in CSCL distinguishes between *internal* (i.e., knowledge of collaborative learning) and *external* (i.e., instructional scaffolds for collaborate learning) *scripts* (Fischer et al., 2013; Kollar, Fischer, & Slotta, 2007). The lack of knowledge of effective learning strategies and weaknesses in judgment of own learning is well-documented in research of self-regulated learning (Bjork et al., 2013). Learners have similar weaknesses in regulation of collaborative learning and require external instructional scaffolds[2]. A recent study showed that instructional scaffolds were the most important factor that predicts students' regulation of interaction with others (Cho & Kim, 2013). This finding only reinforced the consistency with the research about self-regulated learning and interaction of learners with content, i.e., *externally-facilitated regulated learning* was shown to be more effective than self-regulated learning in Web-based learning (Azevedo et al., 2008; Kauffman, Zhao, & Yang, 2011).

To establish a high level of cognitive presence in asynchronous online discussions, the design component of teaching presence needs to provide *students with externally-facilitated regulation scaffolding for participation in online discussions. Scaffolding should guide the students to progress to the level of cognitive presence expected in the course objectives. Externally-facilitated regulation scaffolds should be designed with the special care for students' motivation to participate in online discussions.*

In the study reported in this paper, we focus on standards as a mean to operationalize externally-facilitated regulated learning. Specifically, we looked at the effects of the improved clarity of the task condition to promote standards that learners use in their inquiry process through online discussion and guide them to higher levels of cognitive presence. Moreover, the study assumed standards for motivation, as part of conditions consistent with the Winne and Hadwin (1998), by setting expectations for students to participate in the discussions as part of the course grading scheme.

*2.3.2. RQ2: can we build effective student-led discussions through role assignment?*

Research in CSCL starts from the same premise, deeply recognized in the community of inquiry model (Garrison et al., 2010), that learners do not engage in deep collaborative learning without instructional guidance (Weinberger, Stegmann, Fischer, & Mandl, 2007). CSCL recognizes importance of scaffolding of collaborative learning as knowledge construction though social negotiation (Woo & Reeves, 2007). Collaborative scripts – a key scaffolding approach in CSCL – are used to define, sequence, and assign roles in collaborative learning activities (Kobbe et al., 2007).

Role assignment is a type of collaboration script that has attracted much research attention in CSCL research over the past decade. Strijbos and Weinberger (2010) define roles as "more or less stated functions or responsibilities that guide individual behavior and regulate group interaction (2010, p. 491)," while scripted roles are purposefully "designed to improve both learning processes and outcomes (2010, p. 492)." Role assignment has been empirically tested in CSCL research as an effective approach to increasing the level of knowledge construction, cognitive processing, and argumentation (De Wever, Van Keer, Schellens, & Valcke, 2009; De Wever et al., 2010; Hare, 1994; Schellens, Keer, & Valcke, 2005; Schellens et al., 2007; Strijbos & Weinberger, 2010). These studies identify certain role types as particularly effective for knowledge construction, especially if those roles were assigned timely (De Wever et al., 2010). For example, Schellens et al. (2007) showed that the role of summarizer had a statistically significant positive effect on knowledge construction in a study in which online discussion transcripts were coded with the knowledge construction levels proposed by Gunawardena, Lowe, and Anderson (1997). The summarizer role was found to have had a considerably higher effect

[2] In the field of CSCL, these external instructional scaffolds are commonly referred to as external scripts (Fischer et al., 2013). The major reason for the use of the term "script" lies in the nature of the scaffolds used in CSCL where role assignment is the most commonly used type of instructional scaffolding. Each role in such collaborative learning context is assigned to students through the scripts describing how they should play the role assigned.

on the level of knowledge construction over no role assignment condition.

Role assignment is a promising approach to increasing the level of cognitive presence in communities of inquiry. Although some studies have implicitly used instructional strategies, which had specifically designated roles for students (e.g., WebQuest (Kanuka, 2005)), no study investigated an effect of individual roles on cognitive presence in the community of inquiry model. In order to scaffold knowledge construction in a community of inquiry and help all students move up to the higher levels of cognitive presence (integration and resolution), design and assignment of roles with a single duty does not seem promising, especially in situations when students are requested to work on personalized problems that are assessed individually, which is a common case in junior and senior undergraduate and especially graduate courses. *Therefore, we propose designing roles that will include multiple duties and that will scaffold students' progression throughout the phases of PIM to the highest levels of cognitive presence.* These duties should include opportunities for the initiation of a new inquiry, sharing information and brainstorming, hypothesizing new solutions, and (vicariously) testing the hypothesized solutions. For such roles to be effective, *the specification of the roles should be aligned with externally-facilitated regulation scaffolds that guide students how to contribute to online discussions, as studied in RQ1.*

## 3. Method

### 3.1. Study design

The study reported followed the design-based research method (Design-Based Research Collective, 2003) which is commonly used for studying knowledge construction through social negotiation in online asynchronous discussions (Gilbert & Dabbagh, 2005; Schellens et al., 2007; Swan, Matthews, Bogle, Boles, & Day, 2012). Design-based research involves at least two main types of intervention — instructional and technological (Brown, 1992). Anderson and Shattuck (2012). The interventions studied in this research were *instructional* — externally-facilitated regulation scaffolding and role assignment. Given the naturalistic context and the interventionist method followed, the study was *quasi-experimental* as the researchers did not have a control over the assignment of the participants to the experimental condition (i.e., the students were assigned to the groups through the course enrollment).

Specifically, our study followed a *quasi-experimental mixed design* (Field & Hole, 2003). The *between groups* (i.e., *independent samples*) component of the mixed-design looked at the effects of externally-facilitated regulation scaffolding (i.e., research question RQ1). That is, the initial course design related to asynchronous online discussions was used in the first two offerings of a fully online course — *control group*. This initial course design primarily focused on the extrinsic motivation (i.e., grades) and had a limited scaffolding for the quality of discussion participation. This original design was refined and used for structuring of the asynchronous online discussions in the following four course offerings — *treatment group*. The refinement included an externally-facilitated regulation scaffold guiding students to the expected level of cognitive presence, as proposed in research question RQ1. Furthermore, the *within group* (i.e., *repeated measures*) component of the mixed-design looked at the effects of role assignment and rotation, as proposed in research question RQ2. That is, in both groups (control and treatment), each student was assigned to two different roles as described in Section 3.2. The differences in the numbers of students enrolled into different course offerings, caused by the quasi-experimental nature of the study, led us to have a different number of course offerings per iteration in order to have i) a statistical power necessary for the planned statistical analysis, and ii) the sample sizes in both iterations of the approximately similar size.

### 3.2. Course design and interventions

In our study, we use the data from six offerings of a master's-level research intensive course in software engineering. The course covered selected topics of software engineering related to software requirements, design, implementation, evolution, and process. It was a 13 week long master's level course offered by using the Moodle learning management system. The final grade was based on scores on the four assignments and participation in asynchronous online discussions. In assignment 1 (15% of the final grade), the students were requested to select a peer-reviewed research paper, prepare a presentation of the selected paper, record it in a video format, upload their video recordings to a university-wide software for video sharing and streaming (YouTube-like), and post the URL of their streamed presentation to their peers on an asynchronous online discussion forum. In assignment 2 (25%), the students were requested to prepare a paper reviewing the peer-reviewed literature on a selected topic in software engineering; the papers were assessed by both two peers (double blind) and the instructor. In assignment 3 (15%), the students were requested to answer six questions based on the course readings with the particular emphasis on the synthesis of course readings and critical analysis of different perspectives of importance to modern software engineering research and practice. Finally, in assignment 4 (30%), the students were requested to work in groups of two on a research project that was solving a practical software engineering problem.

The focus of this study was on the asynchronous online discussions that were organized as part of assignment 1. The discussions were in weeks 3–5 of the course and assigned 10% of the final course mark[3]. Each week, one-third of the students enrolled into the course offering were requested to prepare a video-recorded presentation, and the rest of the group was requested to engage into the discussion around the presentations. The guidelines for participation in discussions (RQ1) are available in Appendix A: a) for the control group; and b) for the treatment group (i.e., second iteration). These guidelines were informed by the existing frameworks for facilitating and structuring online discussions (Gilbert & Dabbagh, 2005; Rovai, 2007). As per Rovai's (2007), the guidelines covered the elements of structure. Specifically, the following elements of the structure were included: motivation — by grading student participation in online discussions; expectations — by defining the quality of posts; and task-oriented discussions — by focusing discussions on the particular topics of the presentations and steering discussions towards defining the research problems to be solved in the future assignments. The course revision – treatment group – particularly focused on the expectations component of the guidelines in order to introduce an externally-facilitated regulation scaffold.

Students were assigned two types of roles: *research expert* and *practicing researcher*. Given the complexity of the ill-structured problems students were requested to work on the course (requesting a problem identification and formulation before even starting to work on the solution), need to scaffold the practical inquiry in such a context, and the ineffectiveness of some of the (single-duty) roles reported in the literature (e.g., source searcher), the roles were designed to have multiple functions. In particular, both roles used in our study were built as a composition of existing single-duty roles: *source searcher* — to find relevant information sources in order to propose new ideas, offer counter-point to their peers' posts, express their puzzlement, support their claims (i.e., mostly, to support triggering events and exploration); *theoretician* — to support their claims with the existing body of

[3] The students received another 5% of the final course mark on their participation in general discussions in the course. This was created to offer students unstructured opportunities to connect and build their social presence. These discussions are not included in this study. While very important for educational experience, we could not use them for answering the two research questions of this study due to the difference in the context and the lack of the interventions.

knowledge in software engineering (i.e., exploration and integration); and *summarizer* — to integrate ideas from different posts of their peers or information sources, hypothesize and test new solutions (i.e., integration and resolution). In addition, expert researchers had an additional two single-duty roles: *moderator* — to facilitate discussions in their discussion threads (i.e., process-oriented role) (Schellens et al., 2007); and *topic leader* — to initiate a new discussion topic and act as an (invited guest) expert on the topic (i.e., support exploration, integration, and resolution) (Kanuka, 2011; Tagg, 1994). During the three weeks scheduled for the discussions, each student played the role of: i) expert researcher in one of the three weeks in a thread they created in relation to their presentation; and ii) practicing research in each of the three weeks in the threads led by their peers. With this script of the roles, we aimed to foster student–student discussions with equitable opportunities for participation in the discussions (Johnson, 1981; Rovai, 2007; Schrire, 2006).

### 3.3. Participants

The participants ($N = 82$) were students enrolled in a master's-level research intensive software engineering course. In particular, the participants from the control group were enrolled into the following course offerings (13-weeks long): Winter 2008 ($N = 15$) and Fall 2008 ($N = 23$). The participants from the treatment group were enrolled into the following course offerings: Summer 2009 ($N = 10$), Fall 2009 ($N = 7$), Winter 2010 ($N = 14$), and Winter 2011 ($N = 13$). Of the total number of students, the sample had 10 females (12.2%), which is a typical gender distribution for computing programs (Zweben, 2012). From the analysis, we excluded data of the students who withdrew from the course before the end of the discussion period (Week 5). The total number of posts submitted to the asynchronous discussion forum by the 82 students used in our analysis was 1717. The participants were enrolled in to a master's program in information systems offered at a fully-online comprehensive university in Western Canada. The master's program has two student intakes per year and typically caters to part-time students who usually maintain their regular employment. Enrolled students are not requested to follow any predefined course registration; that is, the program does not follow a cohort-based learning model. However, course prerequisites exist and drive the sequence of course completion. As such, all the students had to take one pre-requisite course – survey of computing and information systems – before enrolling into the course under study. An independent $t$-test did not reveal any significant difference ($t(79) = .25, p = .588$) in the mean values of the students' grades in the pre-requisite course between the control group ($M = 91.85, SD = 5.66$) and the treatment group ($M = 91.82, SD = 6.31$). That is, there were no significant differences between the two groups in the mean values of a proxy of prior-knowledge/ability commonly used in educational research — academic performance in the previous courses.

The first three offerings of the course were instructed by the first author of the paper (Winter 2008, Fall 2008, and Summer 2009). The last three offerings of the course (Fall 2009, Winter 2010 and Winter 2011), included in the study, were taught by an instructor who was not involved in this study, but who completely followed the course design outlined in Section 3.2.

### 3.4. Quantitative content analysis

Media used in asynchronous online discussions forces learners to leave written traces of their communication. Those traces can be used to analyze and interpret knowledge construction developed at the group level and in individual written contributions (Stahl, 2004). Quantitative content analysis is a well-known technique for analysis and interpretation of knowledge construction, cognitive processing, and the three main constructs of the community of inquiry model – teaching, social, and cognitive presence – in asynchronous online discussions (De Wever et al., 2010; Garrison et al., 2001; Gunawardena et al., 1997; Schellens et al., 2007). According to Berelson (1952), quantitative content analysis is "a research technique for the systematic, objective, and quantitative description of the manifest content of communication (p. 18)". Message is the most commonly used unit of analysis in the studies of cognitive presence and knowledge construction (Anderson et al., 2001; De Wever et al., 2010; Schellens et al., 2007).

Specifically, for quantitative content analysis of the discussion messages collected in the study (total 1747[4]), the four categories of cognitive presence were used. For each category, the indicators outlined in and the specification of their socio-cognitive processes outlined by Garrison (2011) were followed. In addition to the four categories of cognitive presence, an additional category – other – was used to code the messages in which no traces of cognitive presence were found. The quantitative content analysis was performed by the first two authors of the paper — coders. The first author was the instructor in the first three offerings of the course; this author also designed the course and the course revision (i.e., scaffold). To avoid the bias of the first author who directly participated in the course, the second author was involved in the study from the quantitative content analysis stage. Both coders had experience with the quantitative content analysis technique through its use in other studies. Both coders initially studied the coding scheme, its indicators, social–cognitive processes and examples as originally introduced by Garrison et al. (2001). A sample thread from the available discussion transcripts was selected randomly, and the coding process was discussed by the coders. Then, the coders coded an additional discussion thread separately, and reconvened to discuss their codes. As a high level of mutual agreement was observed at that time, the coders independently coded messages. Finally, the coders compared their codes and reconciled their coding in the case of an initial disagreement. The overall disagreement was in less than 2% of the analyzed cases (i.e., 32 messages), with high inter-rater reliability (Cohen's kappa of .97).

### 3.5. Data analysis

Considering the hierarchical nesting of the data in the study (i.e., individual students are nested into groups created around the course offerings), the revision of the participation guidelines, and the two roles each student was assigned to, mixed-design multilevel linear modeling was used to answer the research questions. Given that the students are grouped based on their enrollment into the six different course offerings, the individual observations – i.e., the students' posts – could not be considered fully independent due to the similarities shared among the individual students enrolled in the same course offering (Hox & Kreft, 1994). According to Hox and Maas (2002), "even if the analysis includes only variables at the lowest level, standard multivariate models are not appropriate. The hierarchical structure of the data creates problems, because the standard assumption of independent and identically distributed observations is generally not valid." The violation of independence assumption in commonly used multivariate methods is often observed in CSCL research. This violation often leads to underestimation of standard errors, and hence, can result in incorrect inferences about statistical significance (Schellens et al., 2007). As a method robust to this violation, multilevel linear modeling has been widely accepted in CSCL research (Cress, 2008; De Wever et al., 2009, 2010; Schellens et al., 2007).

The data analysis in our study was performed using multilevel linear modeling. In particular, the data in our analysis had three levels: 1) individual messages, 2) students; and 3) course offerings (i.e., groups). In our analysis, the mean values of the messages submitted in each of the four phases cognitive presence were used as dependent variables;

[4] This number of the total coded messages is higher than the number of the messages used in our analysis, due to the exclusion of the students who withdraw from the course before the end of the discussions, as indicated in Section 3.3.

i.e., for each phase of cognitive presence, we created a separate multilevel linear model (i.e., we had four different models). Given the mixed-design nature of our study, the multilevel linear models had two dummy variables as fixed effects denoting

1. *independent samples*: 0 — the students in the course offerings with the original course design, i.e., control group; and 1 — the students in the course offerings with revised course design that included externally-facilitated regulation scaffold, i.e., treatment group;
2. *repeated measures*: 0 — the discussion contributions of the students posted with the practicing researcher role assignment; 1 — the discussion contributions of the students posted with the expert researcher role assignment.

In addition, the interaction of the two dummy variables was added in order to test for the effects of externally-facilitated regulation scaffolding on the students when assigned to the two different roles analyzed in our study.

The distribution of variables was tested for normality using the Kolmogorov–Smirnov and Shapiro–Walk tests. This was further explored using P–P plots. Non-normally distributed variables were transformed using natural logarithm for statistical analysis (Keene, 1995). As the values of all the four dependent variables were log-transformed, the results of multilevel linear models were estimated as geometric mean values. All the analyses were performed by using SPSS v. 19. The effect sizes were reported as Pearson's $r$ (Rosnow, Rosenthal, & Rubin, 2000, Eq. (1)) and interpreted according to Cohen (1992) (i.e., .1 — small, .3 — moderate, and .5 — large).

## 4. Results

Table 1 presents the distribution of the discussion posts based on the level of cognitive presence for both quasi-experimental conditions and role assignments. The total numbers of posts for either role assignment is very close in both quasi-experimental conditions, which corroborates the study design decision about the number of student groups involved in either experimental condition. In the control group, a great majority (78.3%) of the posts of the students with the practicing researcher role assignment stayed at the lower levels of cognitive presence — triggering event and exploration. The students when assigned to the practicing researcher role had a very marginal number of the resolution posts (2.01%) and a slightly better presence of the integration posts (12.08%). On the other hand, the students when assigned to the role of expert researcher had a much higher level of cognitive presence than practicing researchers in the control group. Although the two lowest levels of cognitive presence – triggering events and exploration – were still predominant (59.4% combined), cognitive presence of the contributions to the asynchronous online discussions at the level of integration was more than double of the proportion of integration posts for the students when assigned to the practicing researcher role (i.e., 25.25% vs. 12.08%). While the proportion of the discussion posts in the resolution phase contributed by the students when assigned to the role of expert researcher was relatively low (6.93%), it was still over three times higher than the proportion of the resolution posts of the students when assigned to the role of practicing researchers (only 2.01%).

**Table 1**
The total number of discussion posts and their distribution per cognitive presence phase for both quasi-experimental conditions and role assignments.

| | Cognitive presence type | Practicing researcher | Expert researcher |
|---|---|---|---|
| Control group | Triggering event | 36.47% | 9.90% |
| | Exploration | 41.83% | 49.50% |
| | Integration | 12.08% | 25.25% |
| | Resolution | 2.01% | 6.93% |
| | Other | 7.61% | 8.42% |
| | Number of discussion posts | 447 | 404 |
| Treatment group | Triggering event | 14.09% | 11.14% |
| | Exploration | 35.79% | 30.69% |
| | Integration | 38.03% | 42.82% |
| | Resolution | 4.25% | 11.63% |
| | Other | 8.50% | 6.68% |
| | Number of discussion posts | 450 | 416 |

In the treatment group, the distribution of the asynchronous online discussion across the four levels of cognitive presence reveals a different trend. The students when assigned to the role of practicing researcher still had around ~50% of the messages in the triggering event and exploration phases. However, this represents a drop of ~28% in the distribution of these two lowest levels of cognitive presence as compared to the control group. The results also show a considerable increase in the distribution of the discussion posts at the upper two phases of cognitive presence, whereby there were over 42% of the discussion posts in the integration and resolution phases combined. That is, the distribution of the integration and resolution posts in the treatment group for the students when assigned to the role of practicing researchers was almost three times of the distribution for the students in the control group with the same role assignments. An increase in the distribution of the discussion posts in the integration and resolution phases is also notable for the students when assigned to the role of expert researcher in the treatment group as compared to the control group (from 32.18% in the control group to 54.45% in the control group). That is, an increase of about 1.7 times. This increase seems to be evenly distributed across both integration and resolution phases. Consequently, the proportion of the messages in the two lowest phases of cognitive presence for the students in the treatment group when assigned to the role of expert researcher decreased. The difference in the distribution of the four levels of cognitive presence between the two role assignments in the treatment group are minor (with the notable exception of resolution) as compared to the differences observed in the control group. Finally, it should be noted that the presence of the messages without traces of the four phases of cognitive presence was at a similar level for both groups and role assignments.

In order to investigate the impact of the externally-facilitated regulation scaffold (research question RQ1) and the assignment of the two different roles (research question RQ2) on the level of cognitive presence in asynchronous online discussions, three-level mixed-design multilevel linear models were estimated. Messages (level 1) were clustered within students (level 2) who participated in the discussions of the groups (level 3) created by the students' course enrollment. The variables used in the models are described in Section 3.5. First, we estimated a random intercept null model for each of the four dependent variables. Then, we estimated the models by entering the two dummy variables and their interaction into the models as fixed effects. All the models are shown in Table 2.

The results in Table 2 indicate that the addition of the externally-facilitated regulation scaffold significantly decreased the estimated geometric mean value of triggering events for practicing researchers ($F(1, 5.124) = 8.00$, $p = .035$); the decrease was 45.56% (i.e., $|1 - e^{-0.608}|$) with a high effect size ($r = .78$). The assigned to the role of expert researcher in the control group significantly decreased the estimated geometric mean value of triggering events as compared to practicing researchers in the control group ($F(1, 156.282) = 27.885$, $p < 0.001$); the decrease was 48.06% (i.e., $|1 - e^{-0.655}|$) with a moderate effect size ($r = .39$). Finally, the assignment of the role of expert researcher significantly increased estimated geometric mean value of triggering events in the treatment group as compared to practicing researchers in the control group — i.e. the interaction of the externally-facilitated regulation scaffold and the role assignment was also significant ($F(1, 156.282) = 18.063$, $p < 0.001$); the increase was about 21.96% (i.e., $|1 - e^{(-0.608-0.655+0.668)}|$) with a moderate effect size ($r = .32$). These effects of the two factors and their interaction on the estimated geometric mean values of triggering events are shown in Fig. 1a.

**Table 2**
The estimated values of the three-level models for the four phases of cognitive presence.

| Parameter | Triggering event | | Exploration | |
|---|---|---|---|---|
| | Model 0 | Model 1 | Model 0 | Model 1 |
| Intercept | 0.759 (0.116)** | 1.272 (0.185)** | 1.313 (0.160)*** | 1.484 (0.282)* |
| EFR scaffold | | −0.655 (0.232)* | | −0.184 (0.351) |
| Role assignment | | −0.608 (0.115)*** | | 0.102 (0.138) |
| EFR scaffold[a] | | 0.668 (0.157)*** | | −0.307 (0.189) |
| Role assignment | | | | |
| Level 3 | 0.068 (0.049) | 0.055 (0.045) | 0.139 (0.098) | 0.140 (0.110) |
| Level 2 | – | – | – | – |
| Level 1 | 0.294 (0.033)*** | 0.252 (0.029)*** | 0.366 (0.041)*** | 0.363 (0.041)*** |
| Parameter | Integration | | Resolution | |
| | Model 0 | Model 1 | Model 0 | Model 1 |
| Intercept | 1.195 (0.163)** | 0.566 (0.234) | 0.345 (0.062)** | 0.153 (0.116) |
| EFR scaffold | | 0.731 (0.293) | | 0.088 (0.149) |
| Role assignment | | 0.602 (0.124)*** | | 0.260 (0.097)** |
| EFR scaffold[a] | | −0.452 (0.169)** | | 0.020 (0.133) |
| Role assignment | | | | |
| Level 3 | 0.144 (0.101) | 0.092 (0.080) | 0.013 (0.017) | 0.015 (0.022) |
| Level 2 | 0.003 (0.042) | 0.044 (0.038) | 0.023 (0.027) | 0.039 (0.025) |
| Level 1 | 0.374 (0.058)*** | 0.292 (0.046)*** | 0.212 (0.033)*** | 0.180 (0.028)*** |

Legend: All the estimated values are natural logarithms, due to the transformation of the dependent variables by natural logarithm. The null-models and estimated geometric values are provided in the Supplemental material.
* $p < .05$.
** $p < .01$.
*** $p < .001$.
[a] EFR – externally-facilitated regulation scaffold.

Unlike the observed effects for triggering effects, neither externally-facilitated regulation scaffold in the treatment group for practicing researchers ($F(1, 4.421) = .276$, $p = .625$, $r = .24$) nor expert researcher role assignment in the control group ($F(1, 155.967) = .541$, $p = .463$, $r = .06$) were statistically significant (Table 2). Although Fig. 1b shows a distinct pattern of the two roles in the two different quasi-experimental conditions, the interaction was also not significant ($F(1, 155.967) = 2.640$, $p = .106$, $r = .13$); yet, the value of $p = .106$ indicates a trend towards statistical significance with the decrease of 32.23% (i.e., $|1 - e^{(-0.184 + 0.102 - 0.307)}|$) of the exploration posts created by expert researchers in the treatment group, but with a small effect size ($r = .13$). These effects of the two factors and their interaction on the estimated geometric mean values of exploration posts are shown in Fig. 1b.

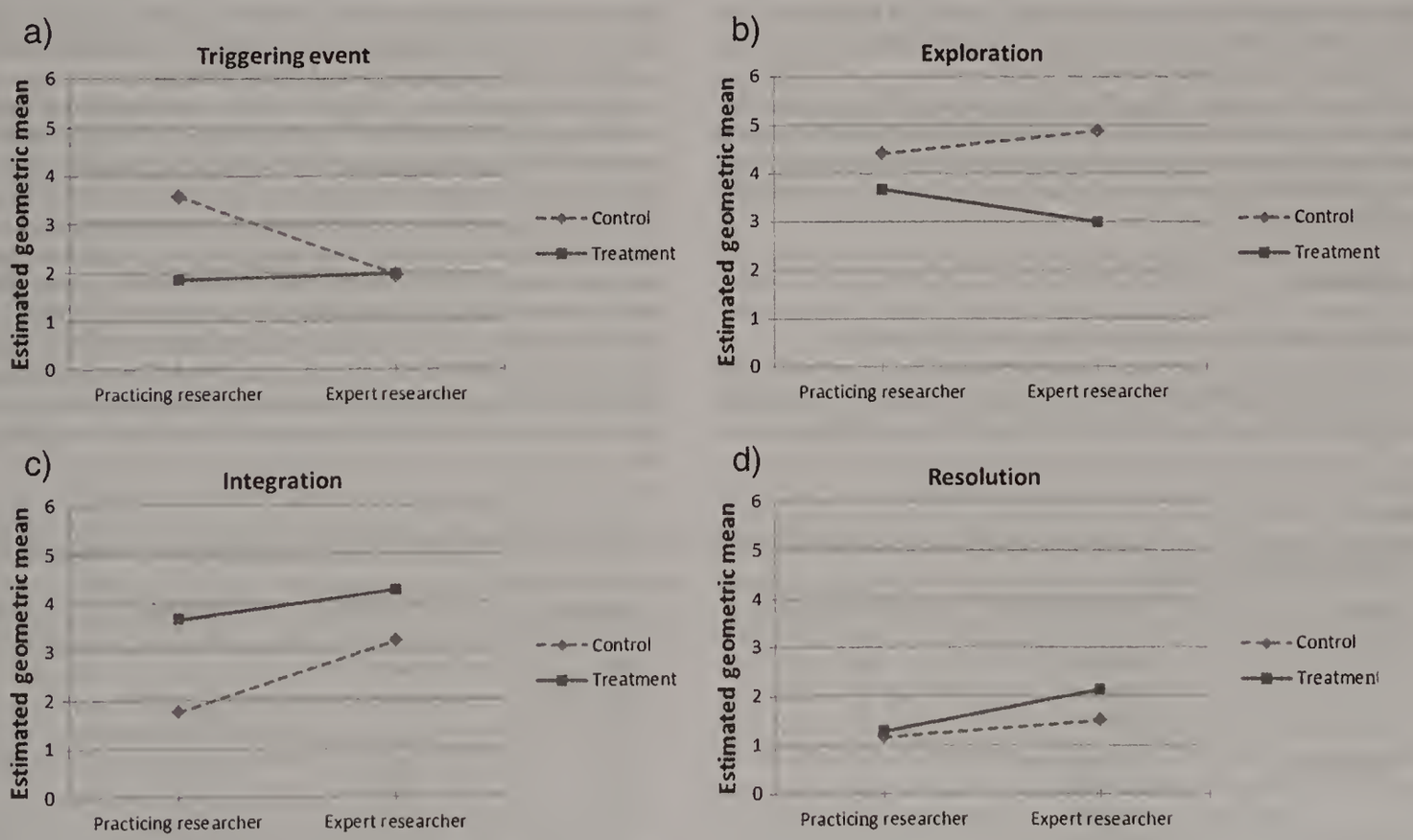


**Fig. 1.** The effects of the interaction of the improved participation guidelines (control vs. treatment group) and the role assignment on the level of cognitive presence.

Although the results in Table 2 show that the externally-facilitated regulation scaffold increased for 107.72% (i.e., $|1 - e^{0.731}|$) the estimated geometric mean value of integration posts for practicing researchers, the increase was not statistically signification ($F(1, 4.088) = 6.235$, $p = .066$, $r = .78$). However, the value of $p = .066$ indicates a clear trend towards statistical significance with a large effect size ($r = .78$). The assignment to the role of expert researcher in the control group significantly increased the estimated geometric mean value of integration posts as compared to practicing researchers in the control group ($F(1, 80.452) = 23.55$, $p < 0.001$, $r = .48$); the increase was 82.57% (i.e., $|1 - e^{0.602}|$) with marginally large effect size ($r = .48$). Finally, the assignment of the role of expert researcher significantly increased the estimated geometric mean value of integration posts in the treatment group as compared to practicing researchers in the control group — i.e. the interaction of the externally-facilitated regulation scaffold and the role assignment was also significant ($F(1, 80.452) = 7.148$, $p = .009$, $r = .29$); the increase was about 141.33% (i.e., $|1 - e^{(0.731 + 0.602 - 0.452)}|$) with marginally moderate effect size ($r = .29$). These effects of the two factors and their interaction on the estimated geometric mean value of integration posts are shown in Fig. 1c.

The positive effect of the assignment of students to the role of expert researchers in the control was statistically significant ($F(1, 81.135) = 7.130$, $p = .009$, $r = .28$) and resulted in the increase of 29.69% (i.e., $|1 - e^{0.260}|$) of the estimated geometric mean value of expert researchers in the control group and with a marginally moderate effect size ($r = .28$), as shown in Table 2. The externally-facilitated regulation scaffold guidelines increased the estimated geometric mean value of resolution posts for 9.20% (i.e., $|1 - e^{0.088}|$) in the treatment group for practicing researchers as compared to the same role assignment in the control group; this increase was not statistically significant ($F(1, 3.549) = .351$, $p = .589$, $r = .30$) though, but the effect size was moderate ($r = .30$). Similarly, the expert researchers in the treatment group had the estimated geometric mean value of the resolution posts for 44.84% (i.e., $|1 - e^{(0.088 + 0.260 + 0.020)}|$) as compared to practicing researchers in the control group; however, this effect of interaction was not statistically significant ($F(1, 81.135) - 0.024$, $p = .878$, $r = .02$) with rather a low effect size ($r = .02$). The effect of the interaction of the two variables is shown in Fig. 1.

Finally, to investigate the effect of the group level of cognitive presence, we extracted the temporal dependencies of the messages from the discussion forums used in our study. Table 3 shows the levels of cognitive presence for responses to the messages which were at particular cognitive presence levels.

## 5. Discussion

### 5.1. Discussion of the results in relation to research questions

In research question RQ1, we investigated the effect of external motivation and externally-facilitated regulation scaffolding on the development of cognitive presence. Consistent with the previous research (Gilbert & Dabbagh, 2005; Rovai, 2007), the results showed that grading asynchronous online discussions was not sufficient to help students reach higher levels of cognitive presence if the participation guidelines were not detailed enough to help students regulate their learning (Appendix A.a). However, the results showed that the introduction of the improved participation guidelines (i.e., externally-facilitated regulation scaffold), produced a desirable effect on cognitive presence. That is, the course design that introduced the externally-facilitated regulation scaffold for participation in asynchronous online discussions, combined with external motivation (i.e., participation grading) resulted in (i) the decrease of the geometric mean values of the posts in the lower levels of cognitive presence (i.e., triggering event and exploration), and (ii) the increase in the upper levels of cognitive presence. Of those, the effect of externally-facilitated regulation scaffold (i.e. treatment) was statistically significant for triggering events only. This effect was so significant by guiding students in the treatment group to produce almost 50% less triggering events. Although not statistically significant (marginally significant, with $p = .066$), the increase of 107.72% in the geometric mean value of integration messages – between practicing researchers in the control and treatment conditions – had a very strong practical significance and a large effect size ($r = .78$).

In research question RQ2, we investigated the effects of role assignment and rotation on cognitive presence. As it was important to support the inquiry process described in PIM, we designed two specific role types — practicing researcher and expert researcher. The results showed desirable effects of the expert researcher role (in the control group) on the level of cognitive presence. The effects of the assignment of this role were similar to those of the improved course guidelines promoting externally-facilitated regulation of online participation: (i) the decrease in the estimated geometric mean values of the lower levels of cognitive presence (i.e., triggering events and exploration) and (ii) the increase in the estimated geometric mean values of the upper levels of cognitive presence. Specifically, the assignment of the expert researcher role compared to the practicing research role resulted in statistically significant effects on the three out of the four phases of cognitive presence, including (i) the decrease of triggering events (48.06%) and (ii) the increase in integration (82.57%) and resolution posts (29.69%).

The most significant finding is that the combined use of the two scaffolding types investigated in the study – role assignment and externally-facilitated regulation – produced the most desirable outcomes — i.e., highest level of cognitive presence. Contrary to our proposition about the importance of designing roles with multiple duties, the results of the study are consistent with previous research on single-function roles (De Wever et al., 2009, 2010; Schellens et al., 2007), which showed that some roles alone were an effective method to promote knowledge construction (i.e., experts researcher), while others were much less so (i.e., practicing researcher). The effectiveness of scripted roles is typically attributed to an explicit specification of the duties a particular student is requested to carry out in a CSCL task

**Table 3**
Dynamics of cognitive presence in a community of inquiry: The frequencies of the cognitive presence level of discussion posts contributed as responses to the messages which were at particular cognitive presence levels.

| Group | Cognitive presence | Triggering event | Exploration | Integration | Resolution | Other |
|---|---|---|---|---|---|---|
| Control group | Triggering event | 178 | 74 | 25 | 5 | 4 |
| | Exploration | 40 | 294 | 14 | 2 | 8 |
| | Integration | 6 | 2 | 114 | 1 | 2 |
| | Resolution | 0 | 1 | 0 | 27 | 1 |
| | Other | | 19 | 0 | 1 | 56 |
| Treatment group | Triggering event | 48 | 56 | 55 | 5 | 11 |
| | Exploration | 16 | 210 | 69 | 10 | 4 |
| | Integration | 2 | 11 | 212 | 3 | 2 |
| | Resolution | 0 | 5 | 5 | 53 | 0 |
| | Other | 1 | 12 | 14 | 0 | 52 |

(Strijbos & Weinberger, 2010). However, our results show that the design of some of the roles should (i) go beyond the design of collaboration duties only and (ii) recognize the social knowledge construction process through the zone of proximal development, as suggested by Woo and Reeves (2007) and stressed in the emerging script theory of CSCL (Fischer et al., 2013). Therefore, the effective role scripts should be accompanied with the participation guidance that are grounded in principles of instructional scaffolding for externally-facilitated regulation (Azevedo & Hadwin, 2005; Cho & Kim, 2013) and recognize the importance of human agency in (social) knowledge construction (Winne, 2005).

Understanding the relation between factors underlying self-regulated learning is of paramount importance for designing effective discussions in communities of inquiry. Dillenbourg, Järvelä, and Fischer (2009) highlighted the importance of studying cognitive and motivational aspects of self-regulated learning in CSCL research. The results of our study offer some evidence that motivation – whether externally induced through grades or internally driven (e.g., by a wish to interact with peers) – was a necessary but not a sufficient factor to establish a high level of cognitive presence. Previous studies showed that a great majority of students would not create more posts to an online discussions forum than it was set in the course expectations (Palmer et al., 2008). On the other hand, our study showed that the students in the treatment group in the role of practicing researchers contributed on average almost two additional integration and resolution messages (i.e., integration $M = 3.659$ and resolution $M = 1.273$) than expected in the course requirements[5]. The interpretation commonly used in self-regulated learning research is that students are capable of self-regulating their own learning, but often forget to do so (Kauffman et al., 2011). Therefore, the combined effect of the externally-facilitated regulation scaffold for participation in discussions with externally-induced motivation through grades had a positive effect on cognitive presence. This offers an important direction for future studies that should investigate different configurations of motivation and externally-facilitated regulation scaffolds on building and maintaining cognitive presence in communities of inquiry.

Ineffectiveness of some scripted roles – such as practicing researcher – was more likely due to the weaknesses in metacognitive monitoring and control, rather than students' unwillingness to leave from their comfort zone, as previously interpreted in research about the community of inquiry model (Richardson & Ice, 2010; Shea & Bidjerano, 2010). Consideration of metacognitive monitoring and control is especially significant in the situations when students are working on ill-structured problems, which as it was the case in our study. As our results indicate, some role scripts already promote the standards the students can use in their metacognition. Given the strong grounding of the students in the work they presented when assigned to the role of expert researchers, they probably accumulated more background knowledge on a particular topic; that allowed them to establish a much higher level of cognitive presence than when they were assigned to the role of practicing researchers in the control group. On the other hand, externally-facilitated regulation scaffolding was necessary for the students when assigned to the role of practicing researchers to establish a high level of cognitive presence. A possible interpretation is that the students, when assigned to the role of practicing researchers, needed more scaffolding on how to integrate their own ideas with those presented by their peers. Thus, practicing researchers achieved a much higher cognitive presence in the treatment group. This is consistent with the finding of Cho and Kim (2013) about instructional scaffolds as the most significant factor for self-regulation of interaction with others, which had previously also been shown to be the case in the research of learning with hypermedia (Azevedo et al., 2008).

[5] The expectation set in the course was three such posts — two synthesis and one innovation posts as outlined in Appendix A.b.

The significant effects of the interaction of the two interventions – externally-facilitated regulation and role assignment – in the multilevel linear models further corroborate the above interpretation about the connection between self-regulated learning and role scripting. The interactions indicate that the externally-facilitated regulation scaffold had significant effects in different directions for the two role assignments. Specifically, triggering events for practicing researchers were considerably decreased (almost double) in the treatment group as compared to the control group, while the externally-facilitated regulation scaffolding hardly resulted in any change in expert researchers. Integration posts for the practicing researchers increased dramatically (107.72%), while the increase for expert researchers was present but not so high between the control and treatment groups. On the other hand, the increase in the number of resolution posts was higher with expert researchers than practicing researchers between the control and treatment groups. Finally, although the interaction effect on the exploration posts was not significant, the diagram in Fig. 1b demonstrates a clear tendency towards significance of the interaction (with $p = .106$, although with a low effect size of $r = .13$). That is, expert researchers had a considerably higher decrease of the exploration posts as compared to practicing researchers between the control and treatment groups.

More equitable knowledge construction opportunities – that promote a balanced cognitive presence for all the students throughout the entire discussion time period regardless of the role assignments – is a significant effect of the interaction of the scripted roles and the externally-facilitated regulation scaffold. Although expert researchers remained to have higher estimated geometric mean values of the posts in the integration and resolution phases than practicing researchers, this difference was considerably reduced in the integration phase between the two role types. The difference however was increased in the number of resolution posts. This seems to be reasonable to happen; an expert researcher would initiate a topic and other students (practicing researchers) were requested to integrate their own topics with the topic presented by the expert researcher. Thus, the practicing researchers likely had to put a considerable higher amount of efforts to reach to the resolution phase than the expert researcher who was paying the role of an expert on the presented topic.

The improved cognitive presence of practicing researchers possibly had a positive effect on the cognitive presence of expert researchers in addition to the externally-facilitated regulation scaffold. The enhanced knowledge construction level of a scripted role was already shown to have a positive effect on students who might not even have a role assignment. For example, De Wever et al. (2010) showed that the students without role assignments reached higher levels of knowledge constructions in the groups in which some students had roles assigned as compared to the groups without role assignments. While the positive effect on the expert researchers could be observed in the treatment group, the opposite could not be inferred from the control group and the impact of high cognitive presence of expert researchers on practicing researchers. A possible explanation could be found in the duties assigned to the expert researcher role. Those duties did not include peer-tutoring and a responsibility to help other students to achieve higher levels of cognitive presence. Rather, their role assignment was to act as experts invited to be responsible for a particular topic. As shown by Kanuka (2011), the invited guest instructional strategy was not most effective to facilitation of higher levels of cognitive presence of entire groups of students. Although the results of the control group confirmed that for practicing researchers, our study showed that the students – at least at the master's level of studies – can effectively assume the duties of invited experts through the expert researcher role. Moreover, when assigned to the role of expert researchers (i.e., invited experts) they reached high levels of cognitive presence.

The results of the temporal dependencies of the messages (see Table 3) showed that in the control group, triggering events typically

led to new triggering events (178), and then to exploration (74), integration, and resolution (5) posts. Furthermore, the results in the diagonal of the table for the both quasi-experimental groups, indicate a clear trend that the responses were most likely to be at the same level of cognitive presence as the message to which they replied. The most notable expectation to this trend is triggering events in the treatment group, where the exploration and integration messages were more probable responses to triggering events than new triggering events. It seems that breaking the "vicious" cycle of triggering events was the critical effect that the externally-facilitated regulation scaffold for participation in discussions played in increasing the overall level of cognitive presence. Of course, this finding requires confirmation in future studies, which will study group dynamics in different settings.

### 5.2. Implications and significance

The results of this study offer new evidence about the importance of studying self-regulated learning and metacognition in communities of inquiry. The positive effects of externally-facilitated regulation corroborate findings of Garrison and Akyol (2013) who defined metacognition as "complementary self and co-regulation that integrates individual and shared regulation". By integrating externally-facilitated regulation scaffolds into the design component of teaching presence, we provided students with the opportunities to co-regulate their learning by following the external standards – provided by "capable others" (Hadwin & Oshige, 2011, p. 247) – the students could use for metacognition of their cognitive presence in communities of inquiry. As such, this study is one of the first attempts that looked into the practical aspects of instructional scaffolding for self-regulated learning in the social knowledge construction process (Järvelä & Hadwin, 2013). In the future research, we plan to look at the implications of scaffolding of more specific phases of self-regulated learning on cognitive presence. Of special importance would be investigation of externally-facilitated regulation scaffolds for different types of roles that might be assigned to students to play in asynchronous online discussions.

Establishing asynchronous online discussions through the instructional design and organization component has significant practical implications. First, it showed that the discussions with a high level of cognitive presence could be organized without a high involvement of instructors into the discussions. Namely, the data collected from the LMS used in the course for the particular discussion form dedicated to the discussions analyzed in this study, indicate that instructor 1 had the following number of discussion contributions in Winter 2008 — 3, Fall 2008 — 4, Summer 2009 — 2; while the number of contributions by instructor 2 was in Fall 2009 — 0, Winter 2010 — 0, Fall 2011 — 2. Second, instructors' workload should necessarily not be increased if the meaningful discussions were to be organized. For this to happen, the course design should apply strategies that will involve students into meaningful discussions. In the case of the study reported in this paper, this was accomplished through externally induced motivation, externally-facilitated regulation scaffolds, and role scripting and assignment. Although the findings of the study indicate the scalability concerns of the communities of inquiry to course of 30–40 students might be overcome (Anderson & Dron, 2011), future studies with larger groups of students should be conducted to validate this scalability hypothesis. In that process, organization of students into groups (of 8–12 students) seems a reasonable strategy, which was already found effective in CSCL research in social knowledge construction activities with role scripting (De Wever et al., 2009, 2010; Schellens et al., 2007).

Integration messages were the most common cognitive presence level observed as the outcomes of the externally-facilitated regulation scaffold and role assignment in this study. The proportion of resolution messages was much lower, which is reported as common in the previous research (Garrison et al., 2001; Kanuka, 2011; Richardson & Ice, 2010). There are several reasons for this:

i) the stage of the course in which the discussions happened was too early to expect many resolutions. The course itself was research-oriented, and as such, the students worked on ill-structured problems. During the stage of the course in which the discussions were organized (weeks 3–5), the students were still working on the identification of a problem for their course projects, which had the completion deadline in the end of the course. Therefore, the higher number of integration messages was desirable, as it allowed students to hypothesize new solutions that were grounded in the research literature and experience of their peers. In the future research, it would be important to study the effect of follow up discussions in the final periods (last 4–5 weeks) of a course (subject of our current study), in which students would discuss their research proposals and the results of their final projects.
ii) the externally-facilitated regulation scaffold did not lead the students to the resolution phase. Consistent with the stage of the course under study described under i), both the upper types of posts outlined in the scaffold used in our study (i.e., synthesis and integration posts in Appendix A.b) could be mapped to the integration phase; i.e., the following two indicators given in connecting ideas, synthesis and creating solutions. That is, the scaffold itself guided the students to the integration phase of cognitive presence. In future research, it would be important to investigate if externally-facilitated regulation scaffolds can be designed in such a way to guide students to reach to the resolution phase of cognitive presence more often than it was the case in our study. Effects of such scaffolds should be studied in different stages of courses in parallel with the study of the issues outlined under i).

The time when a student was assigned to play a particular role – expert researcher or practicing researcher – may have an impact on the cognitive presence of the students. As shown by De Wever et al. (2010), an early assignment of students to particular roles had a strong positive effect on knowledge construction. In future research, it would be important to study the differential effects of the time when a role was assigned and whether the time of role assignment interacts with externally-facilitated regulation scaffolds for participation in discussions. Along those lines, it also seems important to study the effect of fading away instructional scaffolds — including both externally-facilitated regulation scaffolds and role scripting. To test the premise made about the scaffolding for social knowledge construction defined as a zone of proximal development (Woo & Reeves, 2007), future research studies should investigate when and under what conditions the two types of scaffolds can be faded away without affecting the level of cognitive presence of students. The effects of motivation in that process warrant a special attention.

The proportion of the four phases of cognitive presence in asynchronous online discussions requires future research. A recent study reported by Richardson and Ice (2010) showed that undergraduate students generated almost 81% of integration messages in discussions when a case-based instructional strategy was followed. That result contradicts with the findings reported in this and most of other previous studies (Garrison et al., 2001; Pawan et al., 2003). The reasons for such a difference should be studied in future research. The potential reasons could be found in the types of problems the students in a community of inquiry were solving. If working on a well-structured problem, then it is more likely that students would be reaching the integration phase more often. However, if students are working on ill-structured problems, it does not seem reasonable to expect that the students would directly be able to (i) hypothesize solutions or agree/converge in their discussions before first recognizing (i.e., triggering event) and exploring a problem, (ii) and then, being able to propose solutions by integrating different propositions generated by the community or acquired from the available information sources, so that (iii) they can finally test those

solutions. Providing learning opportunities for students and communities to go through all these phases in their inquiry seems very important if the problems are ill-structured with the degree of complexity typical for the graduate level of education, as investigated in the study reported in this paper.

It should be noted that the investigation of the effects of external standards is one possible scaffolding approach to externally-facilitated regulated learning (Azevedo et al., 2008). Future studies should investigate the effects of other types of scaffolds on the level of cognitive presence in communities of inquiry. Of special interest would be dynamic scaffolds that will offer feedback particularly for each individual student. However, such scaffolds could be expensive if they are offered by human instructors, and thus, reduce scalability of the approach studied in this paper. Rather, future research should examine the use of software agents that will be able to automatically analyze online discussion transcripts (Kovanović, Joksimović, Gašević, & Hatala, 2014), gauge the level of cognitive presence, and provide personalized feedback for each individual student.

### 5.3. Limitations

As common for design-based research, this study has potential limitations. First, it is the context in which study was conducted, including, the specific subject area (i.e., software engineering), mode of course delivery (fully online course), the academic level of the course (i.e., master's level), and researchers' bias through the direct involvement in the course teaching and data analysis. While considering these limitations, the following accounts should be taken into consideration. The previous research about communities of inquiry showed the subject area of studies may affect the perceived level of cognitive presence (Arbaugh, Bangert, & Cleveland-Innes, 2010). The community of inquiry model has been successfully tested in both blended and fully-online learning modes (Vaughan & Garrison, 2005). The previous research reported significant differences in perceived cognitive presence between graduate and undergraduate students (Garrison et al., 2010). Therefore, to generalize the findings about the effect of role assignment and externally-facilitated regulation scaffolding on cognitive presence, future studies should be organized in courses from different subject domains, in blended learning settings, and with undergraduate students. Regarding the potential bias induced by the researcher involvement in the course teaching, this was mitigated by having two different instructors, one of whom was not involved in this study as a researcher. Both course instructors followed the same instructional design, which was confirmed by the analysis of trace data about their activity in LMS that was used in the course. Potential bias in data analysis was mitigated by involving additional researchers – second, third, and fourth authors – in data analysis, interpretation of the results, and writing the paper. Neither of them was part of the original course design. Finally, it should be noted that this study did not collect data about individual differences (e.g., prior knowledge, motivation, cognitive load, and self-regulated learning) and perceived value of the students about the course and teaching and the three dimensions of the community of inquiry model. To be able to triangulate the findings and draw inferences about the effects of the proposed externally-facilitated regulation scaffold and role scripting, future studies should collect these data types (Rourke & Anderson, 2004) and study their effect as covariates in the statistical models.

## Appendix A

### A.1. Participation guidance for the control group

For the participation mark (10% of the final course grade), you are expected to participate actively in the presentations of your peers. Participation in a peer's presentation will not be considered just posting a general comment (e.g., "how great the presentation was" or "how you could not understand the voice due to recording"). To develop a constructive discussion around the presented topics, please, make sure that you understand the paper presented by your peers, provide your peers with feedback about their presentation, and post questions related to your peers' presentation and connected ideas on which you can build your research in the following course assignments.

### A.2. Participation guidance for the treatment group

For the participation mark (10% of the final course grade), you are expected to participate actively in the presentations of your peers. Participation in a peer's presentation will not be considered just by posting a general comment (e.g., "how great the presentation was" or "how you could not understand the voice due to the poor audio recording"). Your participation need to be about the content being presenting with the following three levels (from the lowest to the highest quality):

- clarification question – asking about some uncertain parts of the paper being presented;
- synthesis question – asking a question that connects the topics of the presentation at hand with another peer-reviewed paper and its results covered either in the study guide, presentation of another student, or a peer-reviewed research publication;
- innovation question – asking or proposing a novel research topic by making use of the results presented in the paper at hand to draw ideas that are formulating a research problem/challenge. Preferably, the result of a discussion triggered by such a question might result even in the problem formulation of the research to be done in the final assignment of the course.

Every student is expected to have at least two posts in category 2 and one post in category 3. The reset of the questions can fit into category 1.

## Appendix B. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.iheduc.2014.09.006.

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# Toward the development of a metacognition construct for communities of inquiry

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Teaching presence

ABSTRACT

Metacognition is a required cognitive ability to achieve deep and meaningful learning that must be viewed from both an individual and social perspective. Recently, the transition from the earliest individualistic models to an acknowledgement of metacognition as socially situated and socially constructed has precipitated the study of metacognition in collaborative learning environments. This study presents the results of research to develop and validate a metacognitive construct for use in collaborative learning environments. The metacognitive construct was developed using the Community of Inquiry framework as a theoretical guide and tested applying qualitative research techniques in previous research and has been tested in this research by way of developing a metacognition questionnaire. The results indicate that in order to better understand the structure and dynamics of metacognition in emerging collaborative learning environments, we must go beyond individual approaches to learning and consider metacognition in terms of complementary self and co-regulation that integrates individual and shared regulation.

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## 1. Introduction

Metacognition is an important intellectual skill that plays a critical role in learning. Metacognition supervises and controls cognitive processes so that they are executed appropriately and according to superordinate rules (Gourgey, 2001; Necka & Orzechowski, 2005). Research suggests that the ability to monitor and control learning is crucial both for successful learning and learning how to learn (White, Frederiksen, & Collins, 2009). Recently, however, there has been a growing interest in learning communities and metacognitive processes associated with shared cognitive experiences (Chan, 2012). With the increasing focus on learning communities and the need to recognize individual and social regulatory processes, researchers have begun to investigate metacognition in collaborative learning contexts. Flavell (1979) defined metacognition in terms of monitoring and controlling cognition and indicated that metacognition is not only required for communicating, explaining and justifying one's thinking to self but to others as well (Flavell, 1987). Similarly, liskala, Vauras, Lehtinen, and Salonen (2011) also consider metacognition in terms of interaction between an individual or individuals and a surrounding context.

From a broader societal perspective, there is a growing need to understand the process of collaborative thinking and learning in an increasingly connected world as a result of the invasion of ubiquitous communication technologies. Boundaries between the individual and the group are becoming increasingly blurred. As a result, there is a call for more engaged and collaborative approaches to teaching and learning. The question is how is this changing how we think and learn. That is, how do we construct meaning and share understanding in a collaborative learning environment. Simple connectivity is no guarantee of thoughtful collaboration. Metacognition is no longer simply a self-regulated ability and, therefore, must consider issues of shared metacognition and co-regulation.

Considering this perspective, it is argued that metacognition and regulation in collaborative learning environments must go beyond interaction with content and include interaction with others (Cho & Kim, 2013). As a result, there is a pressing need for a construct to study and understand how individuals can be metacognitive in a collaborative learning environment. Moreover, with the increased success of collaborative approaches to learning, it is becoming clear that to better understand the structure and dynamics of metacognition, we must extend self-regulated learning constructs and approaches to include the dynamics of co-regulation of cognition (DiDonato, 2013). To address this, it has been argued that we must articulate the "relationship between regulation and metacognition ... [and] develop conceptual models and frameworks that explicate more clearly the nature and processes of co-regulation" (Chan, 2012, p. 70-71). This is the focus of this research.

The goal of this paper is to "broaden" the study of metacognition to collaborative learning environments. We approached this goal by operationalizing shared metacognition processes through the constructs of self and co-regulation of cognition. We used the Community of Inquiry framework to explicate the shared metacognition construct.

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Within this perspective, metacognition is seen to mediate between internal knowledge construction and collaborative learning activities.

More specifically, the purpose of this paper is to report validation results of the theoretically developed construct of metacognition in a community of inquiry learning environment. Based on a previous study, it was hypothesized that a factor analysis would yield a two factor solution confirming self and co-regulation shared metacognition processes. It is suggested that having a valid and reliable shared metacognitive construct will enhance the understanding of the dynamics and structure of metacognition in collaborative communities of inquiry, leading to further opportunities for the investigation and understanding of shared metacognition. Moreover, a quantitative instrument has the potential to extend qualitative studies of self and co-regulated learning (DiDonato, 2013).

## 2. Community of Inquiry perspective

The shared metacognition construct was explicated within the Community of Inquiry (CoI) framework (Garrison, Anderson, & Archer, 2000). The CoI framework provides a coherent perspective to further study the complex dynamic of collaborative learning environments. Studies of collaborative approaches to learning need to be conducted in a theoretical framework that can concurrently consider the complex interactions of personal cognition and socially shared learning dynamics. The CoI framework was utilized as the theoretical lens in this study for two reasons. First, the CoI framework has been proven successful in describing the inquiry process and has been validated as a coherent theory in understanding the complexities and conduct of learning collaboratively (Garrison, 2011). Secondly, the CoI framework emphasizes both the personal (reflective) and shared (collaborative) worlds of a learning experience, which is consistent with the hypothesized shared metacognitive construct and the integration of the personal and shared view of metacognition proposed here (Akyol & Garrison, 2011; Garrison & Akyol, 2013).

The CoI framework encourages the learner to be self-reflective and communicative in creating the conditions to support and sustain metacognitive development in a collaborative-constructivist learning environment. Learning in a community of inquiry is a reflective and recursive process (Akyol, 2013) which also requires a bidirectional relationship between self and co-regulation. The CoI framework provides the core elements (cognitive, teaching and social presence) essential to study and understand shared metacognition in a learning community. For example, the cognitive presence element of the CoI framework represents the cycle of inquiry that provides a cognitive map of the personal and shared dynamics of the inquiry process and correspondingly the means to study and understand the shared metacognition processes of self and co-regulation. The teaching presence element provides the construct to understand metacognitive development by encouraging students to take personal responsibility for their learning (self-regulation) through facilitating discourse and resolving misunderstandings collaboratively (co-regulation). There is a commonality between the dimensions of teaching presence (design, facilitation and direct instruction) and those of metacognition in terms of monitoring and managing learning through inquiry. Finally, social presence creates an important frame of reference for metacognition. In a community of inquiry, it is the social presence that creates the motivational and academic environment essential for shared metacognition. Collaborative approaches to learning require participants to develop a secure climate in which they can participate and contribute to critical inquiry in order to develop self and co-regulatory metacognition processes.

The impetus behind this research emerged from the idea that learning would be greatly facilitated by an understanding of the metacognitive processes needed to be successful in a collaborative inquiry learning environment. This was reinforced from the perspective that in a collaborative learning environment, metacognition must be extended to consider inherent shared regulatory (monitoring and managing) activities. That is, participants must be aware of and engaged with others' metacognitive thoughts and activities. In previous articles we have defined metacognition as "a set of higher knowledge and skills to monitor and regulate manifest cognitive processes of self and others" (Akyol & Garrison, 2011, p. 184) and provided a thorough review of the metacognition literature (Garrison & Akyol, 2013). Building on this previous research, we argue that the shared metacognitive construct described here has the potential to be developed into an important tool to further explore the shared dynamics of learning collaboratively.

The potential of a metacognitive instrument has the advantage of measuring latent self-regulation that may not be evident in the collaborative discourse found in transcripts of online learning environments. As Delfino, Dettori, and Persico (2008) found that "... when writing messages in online collaborative environments, students are more likely to deal with matters concerning the group rather than themselves as individuals" (p. 201). In collaborative online learning environments, self-regulation may be a latent variable difficult to assess and, therefore, the individual learning dynamic may benefit from an appreciation and assessment provided by an objective questionnaire that reflects the dynamics of both self and co-regulation.

## 3. Evolution of the metacognitive construct

This paper presents the second phase of a research project to develop and validate a metacognition construct for the purpose of understanding the structure and dynamics of metacognition in collaborative learning environments. This research began with a qualitative study that defined a metacognitive construct derived from the literature on metacognition and self-regulated learning. In this study (Akyol & Garrison, 2011), metacognition was hypothesized as consisting of three dimensions: 1) *knowledge of cognition* (KC) as an entering metacognitive state that reflects knowledge and motivation associated with the inquiry process; 2) *monitoring of cognition* (MC) as reflection on action and associated with assessing the learning process (this includes assessing progression and effort with regard to goals and expectations); and, 3) *regulation of cognition* (RC) as the enactment and control of the learning process (reflection in action) which requires employment of strategies to achieve meaningful learning outcomes. The analysis of online discussion transcripts provided evidence to support this metacognition construct (Akyol & Garrison, 2011). Moreover, Snyder and Dringus (2014) found the construct to be "useful in exploring and examining deep instances of metacognition in online discussion forums" (Discussion, first paragraph).

The next step was to further explore this construct quantitatively by developing and testing a metacognitive questionnaire. The questionnaire included questions representing the three dimensions of the previously described metacognitive construct and pilot tested this instrument by administering it to students at a large university in Canada (Garrison & Akyol, 2013). There were 76 students (53 undergraduates; 23 graduates) who completed the questionnaire. Students were also asked to comment on each questionnaire item in terms of its clarity and meaning. Factor analysis was conducted to extract the latent constructs of the questionnaire. However, the factor analytic results were not as hypothesized. Even though the analysis yielded a three factor solution, the factors were not separated in a manner consistent with the qualitative findings of the previous study.

The results of the quantitative analysis directed our attention to a crucial characteristic of the collaborative framework that was not made explicit. That is, the initial metacognitive construct that framed the first phase of this research did not explicitly reflect both individual and shared learning activities (Garrison & Akyol, 2013). More specifically, in a community of inquiry environment, the individual is provided the opportunity to assume appropriate degrees of responsibility to regulate their learning (personal dimension) while receiving collaborative support and direction (shared dimension). Each participant in a community of inquiry has the responsibility not only to construct personal

meaning but also to confirm understanding through discourse. What was clearly missing was the shared or co-regulation of learning central to a learning community.

In the second and current phase of this research project, the metacognition construct and its corresponding quantitative measure were revised to reflect self and co-regulation activities. The revised shared metacognition construct consists of two interdependent elements: self and co-regulation of cognition. Both elements were hypothesized to exhibit a monitoring (awareness) and a managing (strategic action) function. The *self-regulation* of cognition reflects metacognitive monitoring and managing strategies and skills when the individual is engaged in the personal reflective learning process. Self-regulation is what the learner brings to the learning environment and evolves to co-regulation through interactions and engagements in a community of inquiry (Akyol, 2013). The *co-regulation* of cognition dimension reflects metacognitive monitoring and managing strategies and skills when engaged in a collaborative learning process as a member of a purposeful and coherent group of learners. Co-regulation is inherently a collaborative process where internal and external conditions are being constantly assessed. Students are engaged in asking for help or providing help to others to reciprocally enhance the learning experience and the realization of intended outcomes. The previous conceptualization is consistent with the theoretical discussions of Volet, Vauras, and Salonen (2009) in terms of collaboration, regulation and metacognition. They offer a framework that conceptualizes regulation "on a continuum from 'individual regulation within group' to 'co-regulation as a group'" (Volet, Summers, & Thurman, 2009, p. 130; Volet, Vauras, & Salonen, 2009, p. 130). This is dependent upon high-level cognitive and metacognitive processing including critical discourse and negotiation of meaning found in a community of inquiry approach and framework. The CoI framework provided the broader theoretical context for this research, particularly in exploring the intersection of cognitive and teaching presence elements of shared metacognition and regulation. The CoI framework provided a coherent framework to study and understand the metacognitive processes occurring in shared or collaborative learning environments. In this regard, there is a need to not only develop metacognitive constructs associated with shared cognition but also to study this in a theoretically coherent framework that reflects the dynamics of collaborative inquiry.

It is also important to note that Volet, Summers, and Thurman (2009) and Volet, Vauras, and Salonen (2009)place individual and co-regulation on a continuum. Similarly, the two metacognitive dimensions (self and co-regulation) described here are *inter*dependent. As Dewey (1933) argued, the individual and social dimensions of learning are not mutually exclusive. For example, it is hard to imagine how an individual could co-regulate unless they were also self-regulated learners. Therefore, we separate them in this construct only for conceptual clarity while recognizing their interdependence in practice. This assumption is also reflected in the factor analysis described next.

## 4. Method

In the initial phase of this research, an instrument consisting of 54 items was constructed to reflect self and co-regulation responsibilities. These items were derived from our previous qualitative research which offered three dimensions of the metacognition construct (i.e., knowledge of cognition, monitoring of cognition and regulation of cognition) based on a thorough literature review and consistent with the CoI framework (Akyol & Garrison, 2011). However, the factor analysis results indicated a two dimensional metacognition (i.e., self and co-regulation) (Garrison & Akyol, 2013). Therefore, the construct has been revised to reflect the two interdependent dimensions both of which exhibit monitoring (awareness) and managing (strategic action) functions. The difference between the two dimensions reflects the transition from an individual to a shared learning process. The self-regulation of cognition construct includes items that reflect metacognitive monitoring and managing skills when the learner is engaged in the learning process on his or her own. Sample items are: "I am aware of my effort" or "I monitor my thinking process." The co-regulation of cognition construct reflects metacognitive skills when the learner is engaged in the learning process as a member of a group. Sample items are: "I reflect upon others' ideas/comments," "I ask for help" and "I challenge others' perspectives."

Data from a sample of graduate students were factor analyzed. The statistical analysis investigated the internal consistency and the factorial purity of the items of the scale. Respondents were asked to provide feedback on the items regarding their clarity and impressions. The results supported the hypothesized shared metacognition construct. Psychometric properties of the hypothesized items based on this evolved shared metacognition construct and feedback from respondents on the items were used to refine the scale to create the version used for a larger sample confirmation. Several items were reworded to create the final set of items for the exploratory study reported here.

Table 1 provides the items used in this study. Items I1 to I7 were drafted to reflect monitoring strategies of self-regulation, while items I8 to I13 were drafted to reflect managing strategies of self-regulation. Similarly, items G1 to G6 and items G7 to G13 were drafted to reflect monitoring and managing strategies respectively. A Likert scale was used to measure the responses ranging from 1 indicating "very untrue of me" to 6 indicating "very true of me."

### 4.1. Participants

Data from 292 participants were collected initially but reduced to 192 due to missing data. The participants were graduate level students and recruited from a variety of universities across the United States and Canada. The mean age for participants in the study was 39.20 years with a standard deviation of 11.17 years. There were 141 females and 47 males who participated in the study (4 participants did not report their gender). The majority of participants were from graduate programs ($n = 186$) with only three coming from undergraduate programs. Three participants did not report the kind of program that they were in. Eighty-one participants reported receiving their education in an on campus learning environment, while 107 students reported receiving their education in an online learning environment.

### 4.2. Instrumentation and procedure

The shared metacognition questionnaire (see Table 1) reflecting self and co-regulation functions was administered to the participants via "Survey Monkey." Participants were emailed a link to the survey once they expressed interest in participating in the study.

## 5. Data analysis and results

The first priority was to explore the structure of self and co-regulation dimensions of the shared metacognition construct. For this reason an exploratory factor analysis was conducted. A principal components factor analysis was applied using Oblimin rotations with two factors. As seen in Table 2 below, the results confirm the theoretical structure of the metacognitive construct in terms of extracting two factors that are identified as self and co-regulation of cognition.

In order to explore the monitoring and managing sub-elements of self and co-regulation, an exploratory factor analysis was conducted with four factors and an Oblimin rotation. The assumption was that there is a correlation among the factors (individual monitoring and managing; group monitoring and managing) as was the assumption with self and co-regulation. The items did not load as hypothesized. As a result, it was difficult to interpret the monitoring and managing sub-elements of self and co-regulation (Table 3).

To further explore the distinction between monitoring and managing, an exploratory factor analysis was conducted with four factors

**Table 1**
Final list of items for confirmatory study.

| When I am engaged in the learning process as an INDIVIDUAL: | | When I am engaged in the learning process as a member of a GROUP: | |
|---|---|---|---|
| I1 | I am aware of my effort | G1 | I pay attention to the ideas of others |
| I2 | I am aware of my thinking | G2 | I listen to the comments of others |
| I3 | I know my level of motivation | G3 | I consider the feedback of others |
| I4 | I question my thoughts | G4 | I reflect upon the comments of others |
| I5 | I make judgments about the difficulty of a problem | G5 | I observe the strategies of others |
| I6 | I am aware of my existing knowledge | G6 | I observe how others are doing |
| I7 | I am aware of my level of learning | G7 | I look for confirmation of my understanding from others |
| I8 | I assess my understanding | G8 | I request information from others |
| I9 | I change my strategy when I need to | G9 | I respond to the contributions that others make |
| I10 | I search for new strategies when needed | G10 | I challenge the strategies of others |
| I11 | I apply strategies | G11 | I challenge the perspectives of others |
| I12 | I assess how I approach the problem | G12 | I help the learning of others |
| I13 | I assess my strategies | G13 | I monitor the learning of others |

using a Varimax (orthogonal) rotation. This was intended to test the assumption that monitoring and managing functions are independent. This forced separation provided some evidence of the existence of these constructs but does not resolve the theoretical dilemma in terms of their hypothesized inter-dependence.

### 5.1. Comparison of self and co-regulation

Paired *t*-test ($n = 192$) shows that individuals' perception of self-regulation (mean = 4.98, SD = .82) is higher than their perceptions of co-regulation (mean = 4.76, SD = .69). Descriptive statistics show that overall female students' perceptions of self and co-regulation are higher than the perceptions of male students (mean = 4.89, SD = .56, $n = 141$ for females and mean = 4.51, SD = .81, $n = 47$ for males) (Table 4).

## 6. Discussion

The results of this exploratory study provide support for the hypothesized elements of self and co-regulation that constitute the shared metacognition construct. It is argued here that this construct could be extremely useful in guiding metacognitive research and practice in collaborative learning environments. The potential is to open research possibilities and explore practical guidelines in the rapidly growing and evolving area of collaborative approaches to learning made possible by new and emerging communications technology.

However, there was no clear separation of the monitoring and managing functions hypothesized as sub-elements of the self and co-regulation factors. This suggests that it may be difficult to separate the hypothesized constructs in practice; or the items themselves as written do not clearly distinguish the two hypothesized functions. While an orthogonal rotation (assumption of independence) provided some evidence of separation, this raises theoretical questions as to their independence. As such, it is concluded that separation of the monitoring and managing functions in practice is a particular challenge. This may well be due to the latent (i.e., personal reflective) nature of this concept. Learners move between monitoring activities (e.g., assessing learning) and managing activities (e.g., applying a new strategy to enhance learning) imperceptibly. On the other hand, perhaps the quantitative methodologies are

**Table 2**
Factor analysis results with 2 factors: rotated component matrix.

| | Component | |
|---|---|---|
| | 1 | 2 |
| I11 | .867 | |
| I10 | .862 | |
| I9 | .850 | |
| I13 | .841 | |
| I6 | .809 | |
| I2 | .794 | |
| I12 | .785 | |
| I8 | .766 | |
| I7 | .766 | |
| I3 | .738 | |
| I1 | .732 | |
| I5 | .684 | |
| I4 | .634 | |
| G7 | | .794 |
| G8 | | .794 |
| G2 | | .755 |
| G6 | | .753 |
| G4 | | .731 |
| G5 | | .690 |
| G9 | | .677 |
| G3 | | .673 |
| G13 | | .581 |
| G1 | | .522 |
| G10 | | .522 |
| G12 | | .502 |
| G11 | | .463 |

Extraction method: principal component analysis.
Rotation method: Oblimin with Kaiser normalization.

**Table 3**
Four factor results: rotated component matrix.

| | Item | Component | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| I10 | I search for new strategies when needed | .832 | | | |
| I11 | I apply strategies | .829 | | | |
| I13 | I assess my strategies | .824 | | | |
| I8 | I assess my understanding | .761 | | | |
| I12 | I assess how I approach the problem | .758 | | | |
| I9 | I am aware of my level of learning | .733 | | | |
| I6 | I am aware of my existing knowledge | .673 | | | |
| I7 | I change my strategy when I need to | .661 | | | |
| I5 | I make judgments about the difficulty of a problem | .532 | | | |
| I3 | I know my level of motivation | .497 | | | |
| I4 | I question my thoughts | .422 | | | |
| G6 | I observe how others are doing | | .848 | | |
| G5 | I observe the strategies of others | | .777 | | |
| G7 | I look for confirmation of my understanding from others | | .734 | | |
| G8 | I request information from others | | .694 | | |
| G2 | I listen to the comments of others | | .635 | | |
| G4 | I reflect upon the comments of others make | | .628 | | |
| G3 | I consider the feedback of others | | .584 | | |
| G9 | I respond to the contributions of others | | .500 | | |
| G12 | I help the learning of others | | .361 | .303 | |
| G11 | I challenge the strategies of others | | | .910 | |
| G10 | I challenge the perspectives of others | | | .893 | |
| G13 | I monitor the learning of others | | | .560 | |
| I1 | I am aware of my effort | | | | .681 |
| G1 | I pay attention to the ideas of others | | | | .657 |
| I2 | I am aware of my thinking | .459 | | | .613 |

Extraction method: principal component analysis.
Rotation method: Oblimin with Kaiser normalization.
Rotation converged in 19 iterations.

**Table 4**
Comparison of self and co-regulation according to gender.

| | | Mean | SD | SEM |
|---|---|---|---|---|
| Self-regulation | Females | 5.0041 | 0.78980 | .83833 |
| | Males | 4.8338 | 1.06320 | 1.95466 |
| Co-Regulation | Females | 4.8822 | 0.56080 | .61397 |
| | Males | 4.5106 | 0.81209 | 1.53992 |

not the ideal approach to separate monitoring and managing functions since the literature is consistent in stating that metacognition is best realized through discourse (Brown, 1987; Johansson & Gardenfors, 2005; Larkin, 2009). Moreover, as Pintrich, Wolters, and Baxter (2000) have noted, there is often a mismatch between metacognition constructs that propose multiple elements and the empirical data. However, this should not discourage the quest to develop a questionnaire that can distinguish among the monitoring and managing functions as they go to the essence of an individual learning in a collaborative setting.

Finally, this research found that female students had higher co-regulation compared to male students. The literature indicates minor differences on cognitive ability, metacognition and self-regulation especially during preschool and adolescent (Liliana & Lavinia, 2011; Murphy, Eisenberg, Fabes, Shepard, & Guthrie, 1999). For example in the study of Liliana and Lavinia (2011), female and male eighth graders were different on certain dimensions of metacognitive skills such as the perception of performance, the use of prior knowledge, and the use of various learning strategies and monitoring the learning process. Therefore, even though it requires further statistical analysis, the gender difference on self and co-regulation could be related to the differences between males and females in collaborative learning environments. For example, Abramo, D'Angelo, and Murgia (2013) found that women academics demonstrate greater collaborative propensity in research. Even though these differences are related to many other contextual variables, it is worthwhile to further explore the gender differences on self and co-regulation to develop remedial strategies to support metacognitive development.

## 7. Implications for research and practice

The conceptual "fuzziness" surrounding the executive functioning of metacognition has been noted by Tarricone (2011). This was experienced in the previous phase of the present study (Garrison & Akyol, 2013). The challenge experienced by this research was the consistent isolation of the theoretical sub-elements of monitoring and managing learning for each of the self and co-regulation metacognition constructs. This is a challenge for future research as attempts are made to refine the shared metacognition construct developed to understand and explore learning in collaborative learning communities.

Research into self and co-regulation was greatly enhanced by concurrently considering the influences of social, cognitive and teaching presences. The CoI framework provided the theoretical and methodological tools to explore the complexities of metacognition in collaborative and purposeful learning environments. Understanding individual and shared roles and responsibilities when metacognitively regulating learning is an increasingly important area of research as collaborative approaches to learning are increasingly adopted. This is reinforced in a recent study of collaborative learning environments that found students were more engaged in co-regulation (team regulation) than self-regulation (Saab, van Joolingen, & van Hout-Wolters, 2012). However, one must be careful not to read too much into this as it is most likely that self and co-regulation will ebb and flow during a course of study. Certainly longitudinal studies need to be conducted to understand the dynamics of shared metacognition in terms of self and co-regulation.

In addition to confirming the shared metacognition construct, future research needs to focus on the larger theoretical and practical implications of metacognitive processes in collaborative learning environments. The CoI framework offers considerable potential to stimulate and guide future research into mutually supported metacognition. Previously we had noted that an important line of research into metacognition is to explore the interface between teaching presence and cognitive presence in a collaborative learning environment (Garrison & Akyol, 2013). In this regard, it is interesting to note that "metacognitive presence correlated significantly with cognitive presence and students' teaching presence" (Weerasinghe, Ramberg, & Hewagamage, 2012, fifth paragraph, Summary of Results). This would strongly suggest that metacognition does manifest itself primarily at this intersection of cognitive and teaching presence. The other interesting finding in this study is that when the formal instructor was not present, knowledge of cognition was enhanced and "students were involved in more metacognitive monitoring activities" (fifth paragraph, Summary of Results). This suggests that students must be encouraged to become metacognitively aware and active in terms of monitoring and managing the inquiry process. This is exactly the intent of the teaching presence element and further research should explore learners' awareness of the inquiry dynamic if they are to assume shared metacognitive responsibilities (self and co-regulation).

Understanding the dynamics of self and co-regulation is predicated upon understanding their relationship in constructing personal meaning and collaboratively negotiating and confirming understanding. It was argued previously that this is best done with the guidance of a comprehensive and coherent theoretical framework that has been shown to have an extensive theoretical and empirical foundation. Particular focus should be directed to exploring the relationships among the categories of teaching and cognitive presence using the shared metacognitive construct. A related area of investigation would be to understand the interaction between self-regulation (personal reflection) and co-regulation (discourse). More specifically, what are the metacognitive dynamics of monitoring and managing the inquiry process in a collaborative learning environment? Moreover, the confirmation of a metacognition questionnaire would open enormous possibilities to conduct quantitative studies that could extend previous qualitative methodologies. For example, the relationships among the CoI elements (teaching, cognitive and social presence) and metacognitive constructs (self and co-regulation) could be explored. More specifically, what is the dynamic relationship between self and co-regulation overtime in terms of the phases of practical inquiry as manifested in the cognitive presence model; or, what is the nature of the relationship between metacognition (self and co-regulation) and teaching presence (facilitating discourse and direct instruction). The possibilities are numerous, depending on the context and relevant issues.

From a more pragmatic perspective, the question might be how to promote shared metacognition in collaborative online and face-to-face environments? What types of instruction and guidance in terms of the nature of inquiry are needed to increase shared metacognitive monitoring (awareness) and management (strategies)? Does student led discourse increase shared metacognition (Snyder & Dringus, 2014)? How does shared metacognition develop over time? How does class size impact the development of shared metacognition?

The potential value of the CoI framework to guide research and interpret findings is also demonstrated in terms of introducing and exploring the social influences on mutually supported metacognition. This was highlighted in a study of task and social regulation that concluded; "Regulation of social activities positively affected group performance, whereas social interaction negatively affected group performance" (Janssen, Erkens, Kirschner, & Kanselaar, 2012, p. 25). As has been argued and demonstrated in the research using the CoI framework, open communication and group cohesion are dependent upon establishing a secure and supportive learning climate (i.e., social presence) (Garrison, 2011). This, however, raises interesting questions as to the nature of social presence and the impact of purely interpersonal communication (versus purposeful scholarly discourse) on cognitive presence. This issue was raised previously in CoI research (Garrison, 2011). The influence of the multidimensional social presence construct associated with the CoI framework

could be explored more fully using the shared metacognitive construct offered here.

The research possibilities previously described only begin to explore the advantages of a shared metacognitive construct and questionnaire to explore the collaborative nature of learning communities. The confirmation of the construct reported here has the potential to continue developing an important tool to study shared metacognition in collaborative learning environments – whether they are face-to-face or online.

## 8. Conclusion

Based on research associated with metacognition and the Community of Inquiry framework, a shared metacognitive construct was developed and confirmed. The focus was on self and co-regulation of metacognition. Having a clear understanding of self and co-regulation and its role in collaborative inquiry will lead to developing strategies that can effectively support mutually supported metacognition. In this regard, we are hopeful that the shared metacognition construct offered here will stimulate and guide further research into this important area of learning in communities of inquiry. In addition, a valid shared metacognition instrument would greatly facilitate quantitative investigations into metacognition in collaborative learning environments. Certainly a survey instrument would provide methodological efficiencies that would allow the study of larger samples of participants and groups in terms of mutually supported metacognition. The further validation of a shared metacognition instrument needs to be the focus of further research.

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